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FURTHER STUDIES ON THE REACTIONS OF ADULT BLUEBACK SALMON TO INJECTED SALMON AND MAMMALIAN GONADOTROPHINS

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DURING THE SUMMER AND FALL OF 1952, a second experiment was conducted at the Salmon-Cultural Laboratory of the U. S. Fish and Wildlife Service at Entiat, Washington, to explore further the possibilities of hastening the maturation of adult blueback salmon (Oncorhynchus nerka) by injection with gonadotrophic substances.

At the termination of the 1951 experiment (Burrows et al. 1952), in which adult blueback salmon were injected with an extract of chinook salmon (O. tshawytscha) pituitary glands, it was concluded that (1) development of spawning coloration was accelerated, (2) maturation was unaffected, and (3) fertility of the eggs was reduced. Two factors that might have been responsible for the two negative results were considered. One of these factors was the loss of gonadotrophic hormones from the pituitary glands during the time that elapsed between the death of the fish and the collection of the glands. This interval had ranged from 8 hours to 3 days. The other factor considered was the possible antagonistic reaction as a result of using glands that had not been segregated according to the sex of the fish.

The 1952 experiment was designed not only to test these factors but also to expand the studies to include a comparison of single and multiple injections, as well as an evaluation of a mammalian gonadotrophin.

Procedure

Many of the procedures used in the 1952 experiment were identical with those of the previous year, but some procedures differed slightly, and still others differed radically. These changes in technique were, for the most part, improvements developed during the 1951 experiment.

The salmon pituitary glands were collected from adult chum salmon (O. keta) at the Federal fish-cultural station at Quilcene, Washington, in December 1951. With the fish available immediately after spawntaking, it was possible to remove and preserve the glands within 2 to 4 hours after death. The glands collected were segregated according to sex. The method of preservation used in 1952 differed from the 1951 procedure in two respects: first, the chilled acetone used to dehydrate the glands was decanted and then replaced repeatedly with new chilled acetone until the disappearance of all slush indicated complete dehydration; second, the glands were placed in sealed glass bottles and stored while frozen instead of being dried on filter paper and stored at room temperature as before.

In preparation for injection, the frozen salmon pituitary glands were macerated in a chilled 50-milliliter Ten Broeck tissue grinder. A 1-percent saline solution, which had been acidified with acetic acid to pH 4.0, was added to give the desired concentration. The resultant suspension

was kept cold in a salt-ice mixture during injection.

The mammalian gonadotrophin tested was prepared by Dr. Arthur Rinfret at Stanford University. Derived from the anterior lobe of the horse pituitary gland, the material was dried by lyophilization and freed of ACTH. In preparation for injection, this material required simply the addition of enough tap water to produce the desired concentration.

The 1952 experiment began on July 30, 1952, when the first adult blueback salmon were given injections and placed in large rearing ponds, and ended on December 22, 1952, when the last of the resulting fingerlings were stocked in troughs for feeding.

The 1952 experiment was made with seven groups of adult blueback salmon. The fish in the first group (pond 1) were held without injection and thus served as a control for the other groups. The fish in the second group (pond 2) received two 25-milligram injections of mammalian gonadotrophin 3 days apart, although--prior to the development of a short supply of mammalian gonadotrophin--this group had originally been scheduled to receive three injections at 3-day intervals. The fish in the third group (pond 3) received three 195-milligram injections of female salmon pituitary extract, the equivalent of three glands per injection, at 3-day intervals. The fish in pond 4 were divided into two sections, designated as ponds 4-a and 4-b. The fish in pond 4-a were given a single 100-milligram injection of mammalian gonadotrophin; those in pond 4-b were given a single 50-milligram injection of the same material, half of the dose used in pond 4-a. The fish in the sixth group (pond 5) received a single 280-milligram injection of male salmon pituitary extract, the equivalenf of four glands per injection. Those in the last group (pond 6) received a single 260-milligram injection of female salmon pituitary extract, which was also the equivalent of four glands per injection since the female glands averaged slightly smaller than the male glands.

The 500 salmon required for this experiment were to have been distributed as follows: 100 fish each in ponds 1, 3, 5, and 6; 50 fish in pond 2; and 25 fish each in ponds 4-a and 4-b. On July 30 and 31, 1952, the salmon were dip-netted from the fishway at Rock Island Dam and transported in a fish-distribution truck to the Entiat Station. The fish were then taken at random from the truck and placed in the ponds in rotation to insure a uniform size distribution. Later it became evident that a slight error had been made in the distribution, as ponds 1 and 3 received only 99 fish each, pond 2 received 51 fish, and pond 5 received 101 fish. (See table 1.)

The technique of intramuscular injection was identical with that of the previous year. When fish received more than one injection, as in ponds 2 and 3, the fish were seined and then given the new injection on the side opposite that used for a previous injection.

The fish in all ponds were observed each day, and the rate of development of the secondary sexual characteristics was recorded. Dead fish were removed daily and autopsied, and the information was recorded. The average water temperature during the experiment was 58° F., 2° higher than that of the previous year. The average weekly temperatures for the first 2 weeks of the experiment, however, were 60.7° and 61.3° F., the maximum temperatures reaching 67° F.

The ponds were seined periodically, and the fish were checked for maturity. When the first mature females appeared, it became necessary to make examinations daily. All mature females were held in spawning crates and spawned the following day to insure complete ripeness.

Evaluation of the results of sex segregation of the salmon pituitary glands used for injection into the fish in ponds 5 and 6 necessitated a spawning procedure that was slightly different from that used in the other ponds. Each egg-take was divided, by eye, into two halves prior to fertilization. One half was fertilized with males from pond 5, and the other half with males from pond 6. The procedure created four lots with which to study the effects of sex segregation. In lot A, the eggs from pond 6 females, which had received the female pituitary injection, were fertilized

with males from pond 5, which had been given the male pituitary injection. Theoretically, that should have been the natural mating; therefore, it served as the control group for the sex-segregation phase of the experiment. In lot B, the eggs from the pond 6 females were fertilized with males from pond 6, the pond in which both sexes had had the female pituitary injection. The eggs for lot C, taken from pond 5 females, were fertilized with males that were from pond 5, wherein both sexes had had the male pituitary injection. The matings in lots B and C should have indicated whether an antagonistic effect, due to injection with glands of opposite sex, if present, occurred equally in fish of both sexes. In the last group, lot D, eggs from pond 5 females, which had received injections of the male pituitary glands, were fertilized with males from pond 6, which had received injections of female pituitary glands. Theoretically, this mating should have been the most unnatural of the four and, therefore, should have produced such abnormalities as might result from an antagonistic reaction.

All lots of eggs were incubated on hatching trays stacked in standard deep hatchery troughs, and mortalities were recorded during the green-egg, eyed-egg, and fry stages. When they reached the feeding stage, the fish were placed in troughs and fed.

Results

Mortalities in all groups of adult blueback salmon during the 1952 experiment exceeded 60 percent (table 1), whereas mortalities in the 1951 experiment had been less than 40 percent. These high mortalities may be attributed, primarily, to the abnormally high water temperatures encountered. In ponds 2 and 3, however, repeated handling of the fish during this period of high water temperature further increased the mortality; thus, all the fish in pond 3, which received three injections, were lost; while only one female and three males in pond 2, which received two injections, lived to spawn. This injury from handling was characterized by severe erosion of caudal fin and caudal peduncle, accompanied by fungus. During spawning operations later in the experiment, water temperatures were much lower and, although it was necessary to handle all fish daily, injury did not occur.

When autopsied, few fish showed evidence of injury due to the hypodermic needle. Such injury might have occurred when the fish struggled while the needle was entering the flesh.

Close examination of the gonads of the dead fish from the control pond (pond 1) early in the experiment revealed that both sexes were far from maturity. The bright silvery color, the immature appearance of the head and body, and the firmness of the abdomen made positive identification of the sex, by external characteristics, difficult.

Sexual maturity was first detected on the 4th day of the experiment, when the fish in pond 3 were seined for their second injection. Although all fish looked immature, six males exuded milt when they were handled. None of the females in this pond approached maturity. The fish in pond 2, which were also seined that day for their second injection, were immature. The same day, one dead mature male, also lacking spawning coloration, was removed from pond 6, which received the single injection of female salmon pituitary extract.

Normally, the development of spawning coloration precedes maturation of the gonads and thus serves as a crude measure of the degree of maturation. These observations, however, suggest that the pituitary homogenates employed in the present experiment acted primarily to stimulate gonadal maturation and subsequently to increase the output of sex gland hormones, on which depend the secondary sex characters, including color change. By the 6th day, the fish in the three groups which had received injections of salmon pituitary extract displayed slight spawning coloration, enough to distinguish these fish from the other groups. This spawning coloration, accompanied by hooked jaws, enlarged teeth, and humped backs, developed comparatively rapidly in these three groups. In the control group and

TABLE 1.--Numbers of blueback salmon, mortalities, and eggs taken

Pond number:	1	2	3	4-a	4-b	5	6
Pituitary injected:	None	Mammalian	(Female (salmon	Mammalian	Mammalian	(Male (salmon	(Female (salmon
Amount injected:	None	25 mgs.	3 glands	100 mgs.	50 mgs.	4 glands	4 glands
Number of injections:	0	2	3	1	1	1	1
Total number of fish at start	99	51	99	25	25	101	100
Number of males at start	40	20	38	8	8	43	31
Male mortality prior to spawning	17 (42%)	17 (85%)	38 (100%)	3 (38%)	4 (50%)	20 (46%)	15 (48%)
Number of females at start	59	31	61	17	17	58	69
Total female mortality	46 (78%)	30 (97%)	61 (100%)	14 (82%)	12 (70%)	40 (69%)	49 (71%)
Number of females spawned	13	1	--	3	5	18	20
Spawning period, female	9/19--9/30	9/17--9/17	--	9/23--10/6	9/23--9/29	9/17--9/27	9/17--9/25
Total number of eggs taken	36,023	1,686	--	7,849	12,596	45,158	55,771
Average number of eggs per female	2,771	1,686	--	2,616	2,519	2,509	2,789
Average number of eggs per ounce	298	304	--	310	291	348	344

the three groups that had received injections of mammalian gonadotrophin, slight spawning coloration could not be detected until the 20th day.

When the fish in pond 3 were seined on the 7th day for their third injection, most of the males handled were mature. Because of the flaccid condition of the abdomens, 2 dead females that were removed from pond 3 that day also appeared to be approaching maturity. Autopsies revealed that the ovaries were soft and the eggs loosely attached in the follicles. To determine the degree of maturity in ponds 5 and 6, these ponds were also seined on the 7th day. A check of the fish revealed 14 mature males in pond 5 and 11 mature males in pond 6. There were no mature females in ponds 5 and 6, though 3 nearly mature dead females were removed from these ponds on the next (8th) day. These results were very like those reported by Migata (Migata et al. 1952), in whose work the injection of pituitary extracts of carp and bullfrogs into rainbow trout a few weeks before their normal spawning season produced mature males in 1 day but--although some slight degree of maturation was indicated by the relaxed condition of the abdomens--failed to hasten the spawning time of the females.

By the 13th day, all the fish in pond 3 except 1 female had died. Most of the males had matured, and many of the females were within a few days of maturity. On the 29th day, the remaining female, which was nearly mature, died.

A slightly different situation existed in groups that received a single injection of salmon pituitary extract. Examination on the 12th day revealed only 8 mature males in pond 5 and 4 mature males in pond 6--fewer than in the previous examination. In each pond several females were approaching maturity, but none was fully mature. The reduction in number of mature males in ponds 5 and 6 continued; on the 27th day only a few remained. Mortality accounted for but a small part of the reduction. This discrepancy suggested that gonadotrophic injection may have stimulated maturation of some fish for a limited time, to the extent that only part of the sex products were released early. Stripping the fish to test maturity may have removed all of these sex products, so that subsequent examinations of these fish indicated that they were immature. The numbers of mature males in ponds 5 and 6 remained low until the 39th day, when a marked increase was noted.

A possible explanation of the extremely wide range of sexual maturation in those ponds is that the amounts of injected fluid that were actually retained in the muscle tissue may have varied considerably. The struggle of the fish, or any contraction of the muscles during the injection period, tended to expel a portion of the fluid out of the injection aperture, especially when the needle was withdrawn. To prevent this loss, the area in the region of the injection was thoroughly massaged in an effort to diffuse the fluid among the muscles. In spite of the precautions, varying amounts of fluid could have been lost, even after the fish had been returned to the pond. Variations in the amounts of gonadotrophin retained might, therefore, explain the extreme acceleration of development in some individuals and the slight acceleration in others.

On the 42d day, several mature males were found, for the first time, in the control pond (pond 1).

The first mature females appeared in ponds 2, 5, and 6 on the 47th day and were spawned the next day as follows: pond 2, the 1 remaining female; pond 5, 10 females; and pond 6, 6 females. Two days later (the 49th day), 2 mature females appeared in the control pond (pond 1). In ponds 4-a and 4-b, mature females did not appear until the 53d day, several days later than the control pond. As the single injection given to the fish in pond 4-b was equal to the two given in pond 2, and that given in pond 4-a was twice as heavy, it appears that the maturation of the sole remaining female and 2 males in pond 2 on the 47th day may have been pure chance. The sample was obviously reduced to a level too low for significance.

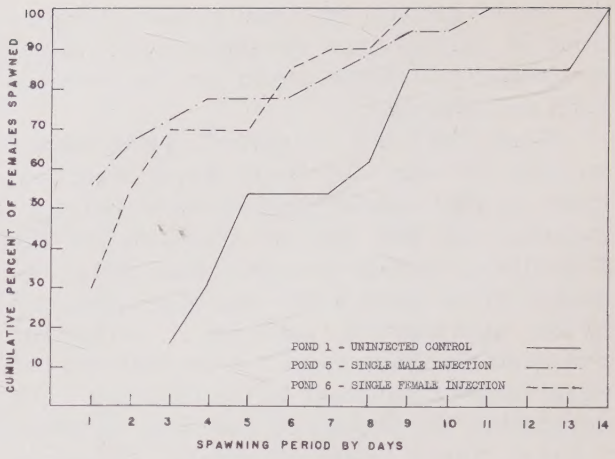
The numbers of females spawned, the spawning periods, numbers of eggs taken, average number of eggs per female, and

average size of eggs, for each group, are shown in table 1. Because of the heavy mortality among the adults during the experiment, it is believed that the number of females which survived to spawn in the ponds originally stocked with only 25 fish (ponds 4-a and 4-b) provided a smaller sample than was necessary for proper evaluation.

The spawning periods for the groups that received the gonadotrophic injections have been compared with the spawning period of the control group and with each other in order to show their relative positions in the spawning period for the entire experiment, an interval of 20 days. The spawning of the fish in pond 4-a, which received the single 100-milligram injection of mammalian gonadotrophin, ranged from the 7th to the 20th day. In pond 4-b, which received half the amount of the same material, the period also began on the 7th day--but ended on the 13th day. No hastening of the spawning periods was apparent in ponds 4-a and 4-b; rather, a tendency to lag was indicated. The role of the mammalian gonadotrophin in the acceleration of maturation of the blueback salmon, therefore, seems doubtful. These results differ considerably from those reported by Kawamura and Ohtsuka (1950), in whose work injection with a manufactured gonadotrophin and with an anterior-pituitary suspension from cattle accelerated development of the ovaries of immature goldfishes.

The spawning periods of the fish in ponds 5 and 6, which received injections of salmon pituitary extract, were similar. Spawning began in both groups on the 1st day; it ended on the 9th day in pond 6 and on the 11th day in pond 5.

Although spawntaking began in ponds 5 and 6 only 2 days earlier than in the control group, comparison of the cumulative percentage of females spawned per day for the three groups (see figure) adds more significance in favor of the gonadotrophic injection. In pond 5, more than 55 percent of the females had been spawned before any eggs were taken in the control pond. Moreover, in pond 6, more than 66 percent of the females had been spawned



Effect of salmon pituitary injection on spawning of blueback salmon.

prior to spawntaking in the control pond. On the third day of the spawning period, when 15 percent of the females in pond 1 (the control) were spawned, more than 72 percent of the females in pond 5 and 70 percent of those in pond 6 had been spawned. Eggtaking was completed 5 days sooner in pond 6 than in pond 1 and 3 days sooner in pond 5 than in pond 1. These data suggest that the injection of blueback with salmon pituitary extract stimulated gonad development and thereby produced a slightly advanced maturity.

The differences in average numbers of eggs per ounce for each group (table 1) suggested that those from ponds 5 and 6, which received the salmon pituitary extract, might have been smaller than those from pond 1 (the control) and ponds 4-a and 4-b, which received the mammalian gonadotrophin. The analysis of variance (Snedecor 1946) of the average numbers of eggs per ounce by individual egg-takes, however, revealed that the differences were not significant. The variation of sizes of eggs within the groups was so great that it obscured the differences between groups.

The results of the sex segregation of the salmon pituitary glands used for injection into the fish in ponds 5 and 6 are summarized in table 2. Mortalities during the green-egg stage were high in all of the

TABLE 2.--Comparative mortalities of eggs and fry from blueback salmon injected with sex-segregated salmon pituitary glands

Lot:	A	B	C	D
Male-pituitary-injected adults from pond 5:	Males	-	(Males, (females	Females
Female-pituitary-injected adults from pond 6:	Females	(Males, (females	-	Males
Total number of eggs taken	23,089	22,069	27,859	27,912
Green egg mortality	9,394	9,860	10,446	11,434
Percentage green egg mortality	40.7	44.7	37.5	41.0
Eyed egg mortality	230	132	94	182
Percentage eyed egg mortality	1.7	1.1	0.5	1.1
Fry mortality	242	213	261	198
Percentage fry mortality	1.8	1.8	1.5	1.2
Total mortality	9,866	10,205	10,801	11,814
Percentage total mortality	42.7	46.2	38.8	42.3

4 lots studied. Differences between lots were slight. There was, therefore, no evidence of antagonistic reactions in lot B, C, or D, in which one or both sexes had been injected with glands from fish of the opposite sex. Analysis of variance of the egg and fry mortalities of individual egg-takes confirmed this conclusion.

The effects that gonadotrophic injection of the adult fish had on the fertility of the eggs and development of the progeny are shown in table 3. Egg and fry mortalities

TABLE 3.--Mortalities during the egg and fry stages

Pond number:	1	2	4-a	4-b	5	6
Pituitary injected:	None	Mammalian	Mammalian	Mammalian	(Male (salmon	(Female (salmon
Amount injected:	None	25 mgs.	100 mgs.	50 mgs.	4 glands	4 glands
Number of injections:	0	2	1	1	1	1
Total number of eggs taken	36,023	1,686	7,849	12,596	45,158	55,771
Green egg mortality	3,582	505	2,101	381	19,254	21,880
Percentage green egg mortality	9.9	30.0	26.8	3.0	42.6	39.2
Eyed egg mortality	426	30	49	38	362	276
Percentage eyed egg mortality	1.3	2.5	0.8	0.3	1.4	0.8
Fry mortality (to feeding)	226	10	47	11	455	459
Percentage fry mortality	0.7	0.9	0.8	0.1	1.8	1.4
Total mortality (to feeding)	4,234	545	2,197	430	20,071	22,615
Percentage total mortality	11.8	32.3	28.0	3.4	44.4	40.5

1 this experiment were somewhat lower than those of the previous year. The total mortality in the uninjected control (pond 1) was, for example, 11.8 percent; whereas the mortality in the corresponding group in 1951 was 29.5 percent. There were also very few defective or deformed fry, in contrast to the large numbers which appeared in all groups in 1951. As no differences due to sex segregation were demonstrated, the groups which received the salmon pituitary injections (ponds 5 and 6) were duplications of each other. Mortalities in these groups were similar and, although slightly lower than those of the corresponding group in the 1951 experiment, confirmed the previous results. The high green-egg mortalities (42.6 percent in pond 5 and 39.2 percent in pond 6, in sharp contrast to 9.9 percent in pond 1, the control) indicated that a lower fertility resulted from injection with the salmon pituitary extract. Eyed-egg and fry mortalities in the three groups were low and were considered normal, as they differed only slightly from each other, further confirming the results of the 1951 experiment. The mortalities in the group that had received 50 milligrams of the mammalian gonadotrophin (pond 4-b) were low during all stages of development and totaled only 3.4 percent, somewhat lower than the mortalities of the control group (pond 1). On the other hand, mortalities in the group that had the 100-milligram injection of the same material (pond 4-a) totaled 28.0 percent, much higher than those of the control group. Examination of the mortalities among individual egg-takes in both groups (ponds 4-a and 4-b) disclosed that although most mortalities were similar, a large portion of the eggs of one of the females from pond 4-a were defective and had 55.3 percent mortality. With only 3 females spawned in that group, the percentage mortality for the entire group was greatly increased. Without that heavy loss of defective eggs, mortalities in pond 4-a would have been low and would have compared favorably with those of pond 4-b and the control (pond 1).

In general, after the infertile eggs had been removed, development of the fertile eggs and hatching and development of the fry appeared normal in all groups. When put in troughs for feeding, the fingerlings fed vigorously and made rapid growth. The mortality at that stage of development remained low.

Summary

The results of the 1952 experiments on the reactions of adult blueback salmon to injections of salmon and mammalian gonadotrophins may be summarized as follows:

1. More than 60 percent of the adult salmon in all groups died because of high water temperatures.

2. Handling affected the loss in both of the experimental groups that received repeated injections.

3. There was a wide variance in the rate of maturation of the fish that received injections of salmon pituitary extract. This variance may have been due to the loss of varying amounts of injection fluid during and after injection.

4. Injection of salmon pituitary extract into adult salmon hastened markedly the development of spawning coloration and other secondary sex characteristics, ripened males as early as 3 days after injection, advanced slightly the spawning period for the females, and lowered the fertility of the eggs.

5. No antagonistic action attributable to sex differences in the injected hormones was demonstrated in this experiment.

6. Injection of mammalian gonadotrophin into adult salmon failed to hasten the development of spawning coloration or other secondary sex characteristics, made no measurable change in the time of maturation, and had no effect on the fertility of the eggs.

Acknowledgments

The authors wish to acknowledge the services of Dr. Arthur Rinfret of Stanford University in preparing the mammalian gonadotrophin used in this experiment.

Literature Cited

Burrows, R. E., D. D. Palmer, and H. W. Newman.
1952. Effects of injected pituitary material upon the spawning of blueback salmon. Prog. Fish-Cult. 14 (3): 113-116.

Kawamura, F., and S. Ohtsuka.
1950. On acceleration of the ovulation in the gold-fish. Japanese Jour. Ichthyology 1 (3): 157-165.

Migata, Masao, Juichiro Matsumote, Hiroshi Kimoshita, Akira Sasaki, and Ichiro Ashikawa.
1952. Studies on the hypophyseal hormone of fishes. 1. Stimulating effect upon the ovulation of trout. Bull. Japanese Soc. Sci. Fish. 17 (8/9): 25-31.

Snedecor, G. W.
1946. Statistical methods. Iowa State Coll. Press, Ames, Iowa. 4th ed., xvi, 485 pp.

NEW STATE PUBLICATIONS

If additional proof were needed, the appearance of new State publications within the last year would demonstrate the growing emphasis upon research studies and the growing recognition of the desirability of making the resultant information more fully and readily available to those who may be expected to make practical and effective use of such information. Sound technical studies in one area are thus being made available for adaptation and application wherever desirable. Of particular interest to fishery workers are two newcomers to the field of fishery literature:

New York Fish and Game Journal. Issued semiannually by the New York Conservation Department, this periodical will be devoted to "presenting the results of research and management studies in New York and other technical papers on related subjects." It is distributed free to official conservation agencies and scientific institutions, to selected libraries and conservation organizations in New York State. Other individuals and organizations may subscribe at a rate of $1.50 per year or obtain individual issues for 75¢ per copy. Correspondence should be directed to the editor: Robert W. Darrow, New York Conservation Department, Albany 1, New York.

Fisheries Research Papers. Apparently this bulletin will be issued by the Washington Department of Fisheries as the accumulation of material warrants such action. Coverage of sport and commercial fishery problems, of management as well as research studies, is indicated. Inquiries about the new bulletin may be made to: Robert J. Schoettler, Director, Washington Department of Fisheries, 1308 Smith Tower, Seattle, Washington.

It is decidedly to the advantage of the general public, and of the angling public in particular, that fishery workers everywhere be fully aware at all times of the progress being made in fishery research and management in various sections of the country. For this reason, the Editors of THE PROGRESSIVE FISH-CULTURIST are always very much interested in learning of any new series of papers devoted to the presentation of fishery data. The Editors consider it a real pleasure to call attention to new sources of information, new outlets for important studies. Any failure to mention, or any delay in welcoming, a new channel for the distribution of data obtained in the course of fishery studies has been an oversight, an unfortunate result of the great number of publications directed to Service personnel. It is suggested, therefore, that the possibility of such an oversight is materially lessened when a publication is directed to the attention of the Editors, THE PROGRESSIVE FISH-CULTURIST.

USE OF PITUITARY MATERIAL IN THE PROPAGATION OF MINNOWS

Robert C. Ball, Michigan State College, East Lansing, Michigan
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A SERIOUS SHORTAGE OF BAIT MINNOWS exists in Michigan and is becoming more critical as the number of anglers on lakes and streams increases. The main sources of bait minnows at the present time are the natural creeks, ponds, and lakes from which they are collected by individual anglers or by bait dealers for sale to the anglers. This supply is often short of the demand, especially during the summer months when fishing intensity is greatest.

To demonstrate the feasibility of rearing bait minnows on a commercial scale, several minnows that are acceptable as bait were propagated in ponds. It was believed that, if it could be demonstrated that the culture of bait minnows in ponds was feasible, commercial minnow dealers would undertake the rearing of their own supply of bait and thus, in part, relieve the pressure on natural populations of minnows in Michigan's waters.

Minnows used extensively for bait, as the fathead minnow (Pimephales promelas), golden shiner (Notemigonus crysoleucas), redbelly dace (Chrosomus eos), and brassy minnow (Hybognathus Hankinsoni), were reared in ponds; and data on life history, growth, production in weight and numbers, and mortality in handling were recorded (Hedges and Ball 1953).

Two other bait fish, the creek chub (Semotilus atromaculatus) and the white sucker (Catostomus commersonii), are very popular as bass and pike bait; but neither can be depended upon to reproduce in ponds, although an occasional crop of young will be produced. Michigan's Institute for Fisheries Research undertook a study of methods of propagating these two species, placing special emphasis on the creek chub because the sucker eggs were available from shoal areas of many lakes in Michigan and because, under favorable conditions, the sucker can be stripped.

As part of the chub-propagation project, a raceway was constructed (Washburn 1948) and proved successful. A second and much improved raceway was constructed at a hatchery in southern Michigan, and improved methods of collecting eggs from the raceway were developed by C. T. Yoder, district fisheries supervisor. This method made possible the supplying of fry to bait dealers, but it had many drawbacks. The raceway method of obtaining the eggs of the chub was expensive because of the labor involved in handling the fish and gathering eggs from the gravel raceways. The loss of eggs was high, and the spawning of the minnows extended over a considerable length of time, which introduced subsequent problems in the distribution of the fry to dealers.

Pituitary glands had been used to induce spawning in certain fish (Von Ihering 1937; Hasler, Meyer, and Field 1940); and it was believed that if hormone injections

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were effective on the creek chub, it would be possible to bring all fish into a ripe condition and strip them at one time. This would greatly facilitate the work of producing fry, as all of the eggs could be obtained within a short space of time and incubated in one lot, and all fry would be ready for distribution at the same time.

To test the practicability of the use of pituitary hormones in the production of bait fish, laboratory and field experiments were planned and carried out during the spring and summer of 1950, using the facilities of Michigan State College and Wolf Lake State Fish Hatchery.

SOURCE AND TREATMENT OF PITUITARY GLANDS

Adult carp (Cyprinus carpio) in breeding condition and weighing between 6 and 8 pounds were obtained for this experiment from Saginaw Bay and inland lakes of southwestern Michigan during the latter part of March and early in April. The fish were received alive at the fishery laboratory at Michigan State College and were kept in holding tanks for a short time prior to removal of the pituitary gland.

The head of the carp was removed, and the brain was exposed by removal of the dorsal surface of the brain case. The broad white ophthalmic nerve, attached to the fore of the brain, was picked up with a pair of tweezers and the entire brain lifted up and laid back. The gland, a small organ resembling an acorn, is located underneath the largest, rounded portion of the brain. Occasionally the gland will remain on the floor of the brain case (figure 1).

The glands were separated according to sex of the fish and then either immediately frozen or dehydrated and defatted in cold acetone for 36 hours. The acetone-treated glands were dried on filter paper and stored under refrigeration till needed.

Whole glands were used in all experiments, no attempt to separate the lobes being made. Just before use, dried glands were pulverized in a mortar and mixed with distilled water; frozen glands were macerated to form a thick suspension in distilled water. No difference between the effects of frozen and dried pituitaries on fish was noted in any of the experiments.

FIGURE 1.--Dissection of a carp head. Top: Brain case removed and brain exposed. Bottom: Brain removed, the pituitary gland remaining on the floor of brain case.

FIGURE 2.--Injecting carp pituitary suspension into creek chub.

LABORATORY TESTS

The experiments on the use of gonadotrophic material to induce the release of sex products in minnows and other fish were begun during the winter of 1950 at the fishery laboratory of Michigan State College and later in the same year were transferred to the Wolf Lake State Fish Hatchery, where large-scale trials were made.

The chubs were obtained from holding ponds at the hatchery at several intervals during the winter and early spring and transferred to the laboratory. All minnows were of breeding size, their length ranging from approximately 9.3 inches for the males to 6.4 inches for the females. The fish readily accommodated themselves to laboratory conditions.

In the laboratory, trials were run on methods of injecting the pituitary material into the fish, amounts necessary to produce release of eggs or sperm, and the viability of eggs obtained by stripping. Ether and urethane (Gerking 1949) were used in the early trials; but their use was discontinued because it appeared that, when used during the stripping procedure, they might be affecting the viability of the eggs. The minimum amount of pituitary material that was effective varied somewhat with the size of the carp from which it was taken, although our tests were not sufficiently sensitive to establish correlation data on this factor.

It was found that the pituitaries from male carp were not so effective on female chubs as the female carp pituitaries but worked well on the male chubs. The glands taken from female carp appeared to work equally well on both male and female chubs.

INJECTION OF MINNOWS

A suspension of carp pituitary and distilled water was drawn up into a 2-cc. glass hypodermic syringe using a No. 19 needle. Injections of the material were made into the back muscles, as done by Von Ihering (1937), and into the musculature at several other points. Almost without exception, the result was a severe swelling, edema, and loosening and raising of the scales in the region of the injection. Nearly all the fish so treated died within a few days.

Further tests showed that injections of the material made intraperitoneally from the ventral surface of the fish at a point anterior to the insertion of the pelvic fins were well tolerated by the fish, and this method was adopted for all further work. The tip of the needle was placed under a scale, pushed through the belly wall into the body cavity, and directed parallel to the ventral surface. As the fish were not anesthetized, the injection required two men--one to hold the fish, and the other to handle the needle (figure 2). This operation proved quite satisfactory and was faster than using ether.

After receiving the injection, the fish were placed in tanks and held until stripping was attempted. With each group

treated, a similar number of untreated fish was held as a control. The loss of fish treated by injection into the body cavity was very low, less than 3 percent in most experiments. Autopsies disclosed that the fish that died soon after injection had been hit by the needle in some vital organ, usually the liver.

Chubs held in the laboratory were kept at 66° to 70° F. after injection. Stripping of the fish was attempted at 12-hour intervals until eggs or milt were obtained or until it was certain that no positive reaction could be expected. Laboratory-held fish received injections of pituitary material in amounts that ranged from one-tenth to one full pituitary, without regard to potency of individual pituitaries. From these preliminary trials it was established that a dosage of one-fourth pituitary was adequate to bring about the desired reaction, and that greater dilutions were not certain to bring about the release of eggs and sperm.

LARGE-SCALE TRIALS

After it had been demonstrated in the laboratory that the carp pituitary injections would induce release of eggs and milt, a large-scale trial was set up at Wolf Lake Hatchery. Three hundred and seven adult chubs were taken from the holding ponds and placed in raceways where daily water temperatures ranged from 46° to 64° F. These fish received injections at the rate of one-fourth pituitary per fish and were returned to the raceways. Forty-eight hours later these fish were stripped and, almost without exception, released all their eggs.

While being stripped, a fish was held over a small enameled pan and the belly wall was gently pressed to force out the eggs. After two or three females had been stripped, a male was stripped into the pan and the milt was mixed with the eggs by gentle rocking of the pan. When the bottom of the pan was covered with eggs, the pan was set aside for about 15 minutes; then small amounts of water were added, and the eggs were washed and allowed to harden for an hour. The eggs were then placed in hatching jars and allowed to complete their development. In the stripping of fish we were greatly aided by hatchery personnel who had considerable experience in the stripping and handling of trout and other fish.

The eggs taken in this way were very clean, and fertilization of them was nearly 100 percent. Very little loss was incurred in the handling of the eggs from the time they were stripped until they hatched. The fry were held until the yolk sacs were nearly absorbed and then were distributed to the commercial dealers throughout the State.

In all of these experiments, untreated fish from each group were held under conditions similar to those under which the treated fish were held. It was very easy to strip the chubs that had received injections, but none of the controls yielded eggs or milt. It appears that the chub does not lend itself to stripping unless activated by injection of pituitary hormone. We have checked many chubs that were ready to spawn and have taken them from the gravel redds while in the act of spawning--and yet have been unable, except for less than 1 percent of the fish, to obtain eggs.

OBTAINING EGGS BEFORE NORMAL SPAWNING PERIOD

Because of the short growing season in Michigan, it is important that minnow producers get the fry into rearing ponds as soon as possible in the spring. To determine how far ahead of the regular spawning season eggs and fry could be obtained, a series of experiments was set up with chub breeders from the overwinter holding ponds. The fish were put in laboratory tanks and acclimated to temperatures equal to or somewhat above their normal spawning temperature of 55° to 60° F. The fish were then treated with carp pituitary in the manner of the previous experiments. The tests were begun 6 months prior to their normal spring spawning period, which was about May 10 in the region where the fish were captured. Viable eggs were first obtained

from fish that had been brought to the laboratory 6 weeks prior to normal stream spawning season. Injections prior to this time caused no recognizable change in the gonads of the fish, even though the fish were held a considerable length of time. There was no evidence of hastening the maturation of eggs or sperm. If a release of sex products was to take place, it was within 48 hours of the time of injection.

Fry obtained from the chubs 6 weeks before their spawning period were planted in ponds, and a close check was kept on their growth rate and survival. From the several ponds it appears that there is little to be gained in Michigan waters by getting the fry into the ponds much before the normal spawning period. In these ponds the minnows were somewhat larger at the end of the summer; but as survival was much lower, it is possible that the slightly faster growth was due to lack of crowding.

EXPERIMENTS WITH OTHER SPECIES AND OTHER PITUITARY PRODUCTS

The lake chubsucker (Erimyzon sucetta) is a species of some importance as a bait minnow. As this species is difficult to propagate, even under favorable conditions, an attempt was made to induce spawning with injections of carp pituitary. Dried pituitary from female carp was injected into a total of 79 fish. These were held under natural spawning temperature conditions.

Injections were very difficult to make in this fish because of the heavy musculature over the belly region. Only a few of these fish yielded eggs or milt, and those responding released only a part of their eggs. Many fish developed an inflamed hard swelling at the point of injection and a fungus condition. Most of the fish were dead in 72 hours. The fish of a control group developed fungus areas but not to the extent to which the treated group did, and the mortality of the control group was low. The few fish remaining alive from the injected group were put in a pond, and apparently the eggs not released during stripping operations were unharmed, as young chubsuckers were seen in the pond later in the summer.

Because the creek chub responded in such a positive manner to the injection of carp pituitary, this fish was used as a test subject for recently isolated and more highly purified mammalian pituitary fractionations.[1/] Male creek chubs produced milt after receiving injections of certain of the following: testosterone, progesterone, stilbestrol, a combination of progesterone and stilbestrol, oxytocin, LH (a) and LH (b) (leutinizing hormones), and FSH (follicle-stimulating hormones). Female creek chubs did not respond to any of the above-named pituitary fractionations in tests during the summer of 1952.

The limited success of these hormones on the creek chub suggests that further work might yield a satisfactory source of hormone that could replace carp pituitary in the production of bait fish and perhaps extend the usage of this tool of fishery management to other species.

HYBRIDIZATION

The production of hybrid fish through the use of hormone injection offers many interesting and practical possibilities, particularly in the management of farm-pond fishes, where the stocking of hybrids has been shown to be advantageous (Ricker 1948). A test, the purpose of which was to show the effect of different pituitaries on several species of fish, was undertaken in the spring of 1953. In the accompanying table are shown the species of fish used, the source of the pituitary, and the results in these tests. All pituitaries other than carp were used in fresh condition and had been taken from the fish during or just before their normal breeding season.

From this table it can be seen that most of the results were negative or, at best, not completely satisfactory. The fish used were captured just prior to their normal spawning time and held in laboratory tanks during the experiment. The

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[1/] Bacon, E. H.: Unpublished report.

RESULTS OF INJECTIONS OF SEVERAL TYPES OF FISH PITUITARY INTO SEVERAL SPECIES OF FISH

Test species	Source of pituitary	Results
Common sucker	Carp	Positive[1]
	Sucker	Negative
Largemouth bass	Carp	Negative
	Largemouth bass	Few eggs
Chub sucker	Carp	Few eggs
	Chub sucker	Negative
	Sucker	Negative
Smallmouth bass	Carp	Negative
	Smallmouth bass	Negative
Redear sunfish	Carp	Negative
	Redear	(Male positive (Female negative
	Bluegill	Negative
Bluegill	Carp	Negative
	Redear	Negative
	Bluegill	(Female negative (Male positive

[1] One of female controls produced eggs.

mortality of the treated fish was low, and none could be attributed directly to hormone injections. These experiments were of an exploratory nature and not in any way conclusive; they pointed out certain possibilities for use of this method of obtaining sperm and eggs. The work indicated need for adequate temperature control, for equipment satisfactory for incubation of the eggs when obtained, and for a ready and adequate source of pituitary material.

SUMMARY

Results of injections of pituitary gland material in these tests are summarized:

1. Creek chubs can be stripped within 48 hours after injection if treatment time approximated normal spawning season. No stripping was possible without injection of pituitary hormone.

2. Viable eggs and normal fry can be obtained by this method approximately 6 weeks prior to normal spawning season.

3. Experiments with other species of fish, using carp, other fish pituitaries, and purified fractionations of mammalian pituitary, have shown contradictory results but enough promise to make further exploration along these lines desirable.

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LITERATURE CITED

Gerking, S. D.
1949. Urethane (ethyl carbamate) in some fishery procedures. Prog. Fish-Cult. 11 (1): 73-74.

Hasler, A. D., R. K. Meyer, and H. M. Field.
1940. The use of hormones for the conservation of muskellunge, Esox masquinongy immaculatus Garrard. Copeia 1940 (1): 43-46.

Hedges, S. B., and R. C. Ball.
1953. Production and harvest of bait fishes in Michigan. Mich. Dept. Cons., Misc. Pub. 6, 30 pp.

Ricker, W. E.
1948. Hybrid sunfish for stocking small ponds. Trans. Am. Fish. Soc. 75 (1945): 84-96.

Von Ihering, R.
1937. A method for inducing fish to spawn. Prog. Fish-Cult. 34: 15-16.

Washburn, G. N.
1948. Propagation of the creek chub in ponds with artificial raceways. Trans. Am. Fish. Soc. 75 (1945): 336-350.

SPRING FISHING ON TWO TVA MAINSTREAM RESERVOIRS. 1945-1953

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A CREEL CENSUS, or record of the catch, gives the fish biologist a lot of valuable information. It indicates fluctuation in quantity and quality of the sport catch. It permits comparisons between different bodies of water or different habitat areas of the same body of water. It reflects changes in the fish population and shows the degree of fishing success.

The mainstream reservoirs of the Tennessee Valley Authority are divided into four more or less distinct areas: (1) a fast tailwater at the head of the reservoir, (2) an upper section where the water is confined to the original channel, (3) a middle section where the water overflows portions of the original river bank and forms large shallow backwater areas to either side of the river channel, and (4) a lower "third" where the water is deep and extends to the steeper slopes bordering the old river basin.

The four areas differ with respect to depth, flow, and turbidity; and they are affected differently by water-level fluctuation. Depth is the least in the tailwater and is greatest in the lower section. The flow is very rapid in the tailwater, is still perceptible in the middle "third," and is almost absent in the lower area. As might be expected, the decrease in flow permits the settling of suspended matter; hence the water in the lower area is normally less turbid than that in the middle or upper areas. The turbidity may be affected by tributaries or by the abundance of rough fish in the backwaters and therefore is not entirely dependent on the rate of flow. Fluctuations in water level influence the middle area much more than the other portions of the reservoir because in the middle area a drop of only a very few feet may expose many acres of bottom in the shallow, but extensive, backwaters.

Owing to the extensive difference in environmental conditions, fish in a mainstream reservoir have access to a variety of habitats, ranging from a fast-flowing river at the upper end of the reservoir to a condition closely resembling that found in normal lakes in the lower section.

Since 1945 a creel census has been conducted on Wheeler Reservoir (1945-53) and on Pickwick Reservoir (1945-50), both mainstream impoundments, in three distinct areas as previously indicated in (1), (3), and (4). The fast tailwater area immediately below Guntersville Dam and at the head of Wheeler Reservoir represents the No. 1 type. The Decatur Harbor area represents the No. 3 type in the creel census. The Stateline Camp area on Pickwick Reservoir represents the No. 4, or slack-water, type in the creel census.

The census was not conducted in 1952 because of lack of funds. It is not a year-round study but is made usually between March 15 and June 30, the average period of best fishing throughout the Valley.

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The 1953 census was unique in that it was conducted jointly by the Tennessee Valley Authority and the Alabama Department of Conservation. The Department of Conservation furnished $1,000 to hire the employees for the creel census. The Tennessee Valley Authority furnished the cards, equipment, and supervision; worked up the creel-census data; and prepared the final report. Here, briefly, are some of the results of the creel census.

Species Composition, Number, Percentage, and Average Weight of Fish March 15 to June 30, 1945 to 1953

Below Guntersville Dam - Wheeler Reservoir (No. 1, Fast Tailwater Area)

For the past 8 years, 18 species have been represented in the catch. Spotted bass and sturgeon were taken in the catch below Guntersville Dam but not in the Decatur Harbor area. In contrast, the longnose gar and the herring were taken in the Decatur Harbor area but not in the area below Guntersville Dam (table 1).

Four species have dominated the catch in the 8-year period: drum, 50 percent; crappie, 21 percent; bluegill, 11 percent; and white bass, 8 percent (table 2). In 1953, however, the catch was dominated by some different species, as compared with the over-all 8-year catch. In 1953, the catch was dominated by the following species: drum, 63 percent; white bass, 13 percent; bluegill and buffalo, 6 percent each. The over-all average of sauger (jack salmon) increased from 1 percent to 4 percent. The increase in sauger was anticipated because the 1951 population studies showed an excellent hatch of this species. The increase in buffalo was due chiefly to the harvesting method for this species -- snatching -- below Guntersville Dam. The average catch in number of fish per trip for the 8-year period was 7.7; for 1953, 7.5; and for 1951, 6.6. The average weight of each fish for the 8-year period was 0.6 pound; for 1953, 0.6 pound; and for 1951, 0.8 pound (table 3). The slight drop below Guntersville Dam may be attributed directly to two happenings of national and regional importance, as follows:

1. Declaration of national emergency in December 1950 by the President. This, for security reasons, restricts movement across the dam.
2. Construction activities due to installation of an additional turbine at Guntersville Dam and, in spring of 1953, the construction of modern rest-room facilities. Both construction projects restricted access to fishing area immediately below the dam.

Decatur Harbor - Wheeler Reservoir (No. 3, Middle Section Area)

Over the 8-year period, 18 species have been represented in the Decatur Harbor catch. In this period, the catch has been dominated chiefly by the following species: crappie, 66 percent; white bass, 10 percent; drum, 7 percent; bluegill, 6 percent; and catfish, 5 percent (tables 2 and 4). The average number of fish taken per trip for the 8-year period was 4.6; for the 1953 census, 2.3 (table 3). The average weight per fish for the 8-year period, and for the year 1953, was 0.8 pound. The drop in the 1953 average catch at the Decatur Harbor area may be attributed, in part, to the following:

1. An unusually cold spring with high winds, especially on weekends.
2. No dewatering at the pumping station for most of census period.
3. Utilization of new boat harbor area as base instead of causeway as in former years.

Stateline Camp - Pickwick Reservoir (No. 4, Lower "Third" Deep-Water Area)

For the period 1945 to 1950, 12 species were represented in the catch at the Stateline Camp area, compared to 18 each below Guntersville Dam and at the Decatur Harbor area (tables 2 and 5). One species distinctly dominated the catch in the lower

TABLE 1.--Summary of creel census, showing the number and percentage of catch represented by each species below Guntersville Dam, Wheeler Reservoir, from 1945 to 1953 (April, May, and June[1/])

Species	Number								
	1945	1946	1947	1948	1949	1950	1951	1953	Total
Largemouth bass	53	147	52	25	50	12	72	67	478
Smallmouth bass	25	8	-	1	10	2	4	8	58
Spotted bass	17	1	-	4	21	-	1	19	63
Crappie	8,774	12,566	10,166	5,461	5,304	4,105	3,534	556	50,466
Sauger	306	212	229	371	121	110	183	720	2,252
Walleye	-	-	-	-	-	-	-	8	8
White bass	2,063	3,956	1,247	2,440	5,026	436	1,303	2,437	18,908
Yellow bass	-	-	-	-	-	-	-	41	41
Drum	28,360	33,262	11,137	16,109	6,795	11,238	3,909	11,503	122,313
Catfish	2,685	2,566	1,148	888	820	349	600	543	9,599
Bluegill	8,373	5,570	3,517	3,073	2,103	2,019	1,230	1,011	26,896
Rock bass	53	42	-	-	3	-	-	-	98
Carp	1,166	1,668	1,792	879	358	634	300	254	7,051
Buffalo	568	737	983	431	351	-	264	1,115	4,449
Sturgeon	-	1	2	-	-	-	4	1	8
Scaley cat	-	-	-	-	1	-	-	-	1
Sucker[2/]	13	11	36	5	3	4	1	51	124
Spoonbill	-	9	21	3	23	14	30	36	136
Total	52,456	60,756	30,330	29,690	20,989	18,923	11,435	18,370	242,949

	Percentage								
Largemouth bass	-	-	-	-	-	-	1	-	-
Smallmouth bass	-	-	-	-	-	-	-	-	-
Spotted bass	-	-	-	-	-	-	-	-	-
Crappie	17	21	34	18	25	22	31	3	21
Sauger	1	-	1	1	1	1	2	4	1
Walleye	-	-	-	-	-	-	-	-	-
White bass	4	7	4	8	24	2	11	13	8
Yellow bass	-	-	-	-	-	-	-	-	-
Drum	54	55	37	54	32	59	34	63	50
Catfish	5	4	4	3	4	2	5	3	4
Bluegill	16	9	12	10	10	11	11	6	11
Rock bass	-	-	-	-	-	-	-	-	-
Carp	2	3	6	3	2	3	3	1	3
Buffalo	1	1	3	2	2	-	2	6	2
Sturgeon	-	-	-	-	-	-	-	-	-
Scaley cat	-	-	-	-	-	-	-	-	-
Sucker[2/]	-	-	-	-	-	-	-	-	-
Spoonbill	-	-	-	-	-	-	-	-	-
Total	100	100	101	99	100	100	100	99	100

[1/] 1951 creel census terminated June 16 because of lack of funds.
[2/] Includes carpsuckers, redhorse suckers, and blackhorse suckers.

NOTE: In addition to the figures shown in the table for 1953, 2,236 fish were taken during the period March 20-31, 1953. The March figures are not included in this table because it has been set up on a comparative basis to cover the period April 1 through June 30. During the years 1945 to 1953, the census did not always begin in March.

TABLE 2.--Comparative summary of creel census, showing the number and percentage of catch represented by each species in lower lakes area, 1945 to 1953 (April, May, and June)

Species	Total			Percentage		
	Below Guntersville Dam	Decatur Harbor Area	Stateline Camp	Below Guntersville Dam	Decatur Harbor Area	Stateline Camp[1]
Largemouth bass	478	629	818	-	2	1
Smallmouth bass	58	53	269	-	-	-
Spotted bass	63	-	2	-	-	-
Crappie	50,466	27,244	53,704	21	66	96
Sauger	2,252	11	75	1	-	-
Walleye	8	1	1	-	-	-
White bass	18,908	4,125	194	8	10	-
Yellow bass	41	1,214	-	-	3	-
Drum	122,313	2,657	52	50	7	-
Catfish	9,599	2,192	315	4	5	1
Bluegill	26,896	2,460	596	11	6	1
Rock bass	98	13	2	-	-	-
Carp	7,051	315	45	3	1	-
Buffalo	4,449	116	-	2	-	-
Scaley cat	1	2	-	-	-	-
Sturgeon	8	-	-	-	-	-
Sucker[2]	124	1	-	-	-	-
Longnose gar	-	2	-	-	-	-
Herring	-	2	-	-	-	-
Spoonbill	136	5	-	-	-	-
Total	242,949	41,042	56,073	100	100	99

[1] No creel census after 1950 because of lack of funds.
[2] Includes carpsucker, redhorse sucker, and blackhorse sucker.

TABLE 3.--Spring creel census, showing average catch and average weight on Wheeler and Pickwick Reservoirs, from 1945 to 1953

Year	Average catch			Average weight		
	Below Guntersville Dam[1]	Decatur Harbor Area[2]	Stateline Camp Area[3]	Below Guntersville Dam	Decatur Harbor Area	Stateline Camp Area
1945	5.4	2.3	5.2	0.4	0.7	0.5
1946	8.4	3.0	3.4	0.4	0.8	0.5
1947	7.1	3.4	3.6	0.5	0.8	0.5
1948	10.1	3.9	5.5	0.5	0.8	0.8
1949	8.1	5.4	4.8	0.6	0.8	1.0
1950	8.4	5.0	4.8	0.6	0.9	0.8
1951	6.6	5.7	No census	0.8	1.0	No census
1952	No census	No census	No census	No census	No census	No census
1953	7.5	2.3	No census	0.6	0.8	No census
Average	7.7	4.6	4.6	0.6	0.8	0.7

[1] Creel census periods as follows:
1945-46 (April 1-June 30)
1947-50 (March 15-June 30)
1951 (March 15-June 16)
1953 (March 20-June 20)

[2] Creel census periods as follows:
1945-46 (April 1-June 30)
1947-50 (March 15-June 30)
1951 (March 15-June 15)
1953 (March 20-June 25)

[3] Creel census periods as follows:
1946 (April 1-June 30)
1947 (March 18-June 30)
1948-50 (April 1-June 30)

TABLE 4.--Summary of creel census, showing number and percentage of catch represented by each species in the Decatur Harbor area, Wheeler Reservoir, from 1945 to 1953 (April, May, and June[1])

Species	Number								
	1945	1946	1947	1948	1949	1950	1951	1953	Total
Largemouth bass	34	19	67	105	80	90	63	171	629
Smallmouth bass	-	2	14	-	12	4	17	4	53
Crappie	1,995	1,981	1,652	1,041	5,161	5,533	3,548	6,333	27,244
Sauger	-	-	-	-	3	-	-	8	11
Walleye	1	-	-	-	-	-	-	-	1
White bass	916	496	72	658	593	236	309	845	4,125
Yellow bass	69	114	130	354	304	203	40	-	1,214
Drum	66	286	549	642	339	432	133	210	2,657
Catfish	125	127	411	467	338	257	103	364	2,192
Bluegill	93	73	259	253	329	296	402	755	2,460
Rock bass	12	-	-	-	1	-	-	-	13
Carp	40	24	66	51	56	19	14	45	315
Buffalo	43	2	7	10	16	18	27	3	116
Scaley cat	2	-	-	-	-	-	-	-	2
Longnose gar	-	1	-	1	-	-	-	-	2
Sucker[2]	-	-	-	1	-	-	-	-	1
Herring	2	-	-	-	-	-	-	-	2
Spoonbill	1	-	-	-	-	-	-	4	5
Total	3,399	3,125	3,227	3,583	7,232	7,078	4,656	8,742	41,042

	Percentage								
Largemouth bass	-	1	2	3	1	1	1	2	2
Smallmouth bass	-	-	-	-	-	-	-	-	-
Crappie	59	63	51	29	71	78	76	72	66
Sauger	-	-	-	-	-	-	-	-	-
Walleye	-	-	-	-	-	-	-	-	-
White bass	27	16	2	18	8	3	7	10	10
Yellow bass	2	4	4	10	4	3	1	-	3
Drum	2	9	17	18	5	6	3	2	7
Catfish	4	4	13	13	5	4	2	4	5
Bluegill	3	2	8	7	5	4	9	9	6
Rock bass	-	-	-	-	-	-	-	-	-
Carp	1	1	2	1	1	-	-	1	1
Buffalo	1	-	-	-	-	-	1	-	-
Scaley cat	-	-	-	-	-	-	-	-	-
Longnose gar	-	-	-	-	-	-	-	-	-
Sucker[2]	-	-	-	-	-	-	-	-	-
Herring	-	-	-	-	-	-	-	-	-
Spoonbill	-	-	-	-	-	-	-	-	-
Total	100	100	99	99	100	99	100	100	100

[1] 1951 creel census terminated June 15 because of lack of funds.
[2] Includes carpsuckers, redhorse suckers, and blackhorse suckers.

NOTE: In addition to the figures shown in the table for 1953, 936 fish were taken during the period March 20-21, 1953. The March figures are not included in this table because it has been set up on a comparative basis to cover the period April 1 through June 30. During the years 1945 to 1953, the census did not always begin in March.

TABLE 5.--Summary of creel census, showing number and percentage of catch represented by each species at Stateline Camp, Pickwick Reservoir, from 1945 to 1950[1] (April, May, and June)

Species	Number						
	1945	1946	1947	1948	1949	1950	Total
Largemouth bass	35	203	73	189	183	135	818
Smallmouth bass	28	8	2	17	28	186	269
Spotted bass	-	-	-	-	2	-	2
Crappie	12,375	5,937	3,259	9,746	12,601	9,286	53,704
Walleye	-	-	1	-	-	-	1
Sauger	-	6	12	5	40	12	75
White bass	25	14	5	20	39	91	194
Drum	8	5	4	7	12	16	52
Catfish	42	47	29	21	80	96	315
Bluegill	60	174	86	86	81	109	596
Rock bass	-	2	-	-	-	-	2
Carp	5	23	7	4	-	6	45
Total	12,578	6,419	3,478	10,095	13,066	9,937	56,073
	Percentage						
Largemouth bass	-	3	2	2	1	1	1
Smallmouth bass	-	-	-	-	-	2	-
Spotted bass	-	-	-	-	-	-	-
Crappie	98	92	94	97	96	93	96
Walleye	-	-	-	-	-	-	-
Sauger	-	-	-	-	-	-	-
White bass	-	-	-	-	-	1	-
Drum	-	-	-	-	-	-	-
Catfish	-	1	1	-	1	1	1
Bluegill	1	3	2	1	1	1	1
Rock bass	-	-	-	-	-	-	-
Carp	-	-	-	-	-	-	-
Total	99	99	99	100	99	99	99

[1] No creel census after 1950 because of lack of funds.

"third" or Stateline Camp area, while three and four species were dominant in the other two areas. Over the 6-year period, crappie dominated the catch with a grand total percentage of 96. This percentage of crappie dominance ranged from 92 percent through 98 percent (tables 2 and 5). Three other species--largemouth bass, catfish, and bluegill--made up a grand percentage of 1 each in the catch over the 6-year period.

The average catch per trip for the 6-year period was 4.6 fish, compared to 4.6 fish for the Decatur Harbor area and 7.7 fish in the area below Guntersville Dam (table 3). The average weight of the fish in the Stateline Camp area was 0.7 pound, compared to 0.8 pound for the Decatur Harbor area and 0.6 pound below Guntersville Dam.

Average Catch Per Fishing Trip March 15 to June 30, 1945 to 1953

Below Guntersville Dam

The average catch per fishing trip in the area below Guntersville Dam over an

8-year period is shown in table 6. During this period, the average catch per fishing trip was 7.7 fish weighing 4.2 pounds. The 1953 census figures in comparison were 7.5 fish weighing 4.5 pounds. The 0.8-pound drop in the average number of pounds per fishing trip after 1951 may be credited in part to the smaller average size of the drum and the crappie in 1953. The decrease may be due also to a change in the population. The catch of crappie decreased from 31 percent in 1951 to 3 percent in 1953. The catch of drum increased from 34 percent in 1951 to 63 percent in 1953. As stated above, the drum and crappie were of a smaller average size in 1953; hence the reduction in catch weight.

TABLE 6.--Spring creel census, showing catch per fishing trip, Wheeler and Pickwick Reservoirs, 1945 to 1953 (March 15 to June 30)

Year	Guntersville Dam Area		Decatur Harbor Area		Stateline Camp Area	
	Number	Pounds	Number	Pounds	Number	Pounds
1945	5.4	2.2	2.3	1.7	5.2	2.6
1946	8.4	3.4	3.0	2.6	3.4	1.7
1947	7.1	3.6	3.4	2.8	3.6	1.7
1948	10.1	5.1	3.9	2.9	5.5	4.4
1949	8.1	4.9	5.4	4.0	4.8	4.9
1950	8.4	5.0	5.0	4.7	4.8	3.8
1951	6.6	5.3	5.9	5.9	No census	
1952	No census		No census		No census	
1953	7.5	4.5	2.4	1.7	No census	
Average	7.7	4.2	4.6	3.3	4.6	3.2

Decatur Harbor Area

The average catch per fishing trip at the Decatur Harbor area over an 8-year period is shown in table 6. The average catch per fisherman was 4.6 fish weighing 3.3 pounds. The 1953 census figures in comparison were 2.4 fish weighing 1.7 pounds. Except for the factors previously listed in this paper, the reason for the decline at Decatur Harbor is not known. The catch for 1953 consisted of the same kinds of fish in the same proportions as in 1951. The crappie, however, averaged 0.9 pound in 1951 and 0.7 pound in 1953. The crappie made up 72 percent of the catch in 1953. Out of 8,742 fish checked in the 1953 census, 6,333 were crappie. In like manner, other species that dominated the 1953 catch also had a lower average weight that year than in 1951.

Stateline Camp Area

Over the 6-year period from 1945 to 1951, the average catch per fishing trip was 4.6 fish weighing 3.2 pounds (table 6). This compares very closely with 4.6 fish weighing 3.3 pounds in the Decatur Harbor area. The similarity of the results for these two areas is due chiefly to the fact that they do not have the fast current typical of the tailwater area at the head of the reservoir. The No. 3 type and No. 4 type areas (Decatur Harbor and Stateline Camp) have less current, less turbidity, and greater depths. In these respects they more closely resemble conditions found in normal lakes.

The average weight of the crappie in the Stateline Camp area ranged from 0.7 to 1.0 pound during 1950, the last year of the creel census at this station. Frequent spot checking of this area since that time by Tennessee Valley Authority and State officials indicates that the crappie still distinctly dominates the catch.

Summary and Discussion

A creel census was taken, beginning in mid-March and continuing through June, at three localities on two TVA mainstream reservoirs from 1945 through 1953. No creel census was taken in 1952 because of lack of funds. This work should be continued indefinitely to determine trends in the fish catch. So far, neither the creel census nor the tagging studies indicate

that the catch by year-round fishing is excessive.

The TVA mainstream reservoirs are large, totaling about 448,000 acres in area. Fishing pressure still remains moderately light. In these reservoirs angling has little apparent influence on the relative abundance of fish of various species. Our harvesting equipment, the hook and line, is inefficient "machinery." Our lures must compete with natural food. It seems almost impossible to harvest, by hook-and-line fishing, so much of the crop that an inadequate broodstock remains.

DRIED DISTILLERS' SOLUBLES USED IN DIET OF SALMONOID FISHES

The use of dried distillers' solubles throughout 1953 as a practical ingredient in the dry feed mixture at a 24-percent level, incorporated as a substitute for powdered skim milk, is reported to have resulted in over-all gains and conversions which exceeded those obtained during the preceding year with the Standard Cortland Dry Feed Mixture No. 6.

"Not only did the distillers' solubles replace powdered skim milk, the more expensive ingredient, reducing our food cost for calendar year 1953 by $17,868.27," writes Bernard W. Corson, Chief of Fisheries Division, New Hampshire Fish and Game Department; "these solubles also resulted in growth rates that exceeded those of the Standard diet."

In the past, according to Mr. Corson, the meat-dry feed diets used in their fish-cultural program have consisted of 15 percent beef liver, 35 percent beef melts, and 50 percent meal, with only minor variations. This mix is fed to salmon, brook, rainbow, brown, and lake trout when they reach the 2- to 4-inch size group.

In January 1953, however, a shortage of powdered milk led to the development of a formula utilizing the dried distillers' solubles at a 24-percent level. Use of this formula was continued during the next 12 months. The change in diet composition was then evaluated by comparing (see tabulation) food-cost and conversion data for 1953 with those data for 1952.

It appears that the introduction of the dried distillers' solubles at the level of 24 percent in the dry mix has reduced the dry-food cost by 25 percent and provided an over-all increase of 13 percent in the total poundage of trout produced. The improved gains and conversion apparently must be attributed to the formula. It was used at nine hatcheries and rearing stations that previously maintained the same carrying capacity. Also, as Mr. Corson notes, the water sources for these hatcheries and rearing stations "have negligible variances in temperature from year to year which would not result in any demonstrable difference in the growth rate of the five groups of trout fed the same diet."

	1952	1953
Diet	Meat-dry feed (Cortland No. 6)	Meat-dry feed [1]
Total cost of food fed	$82,075.13	$64,206.86
Total pounds of food fed	892,121	891,762
Average cost of food per pound	$0.092	$0.072
Total pounds of trout produced [2]	233,799	264,221
Conversion	3.82	3.37
Fish food cost per pound produced	$0.351	$0.243

[1] 24 percent wheat middling, 24 percent cottonseed meal. 24 percent whitefish meal, 24 percent dried distillers' solubles, 4 percent salt.

[2] Includes salmon, lake, brook, brown, and rainbow trout.

AN INFESTATION OF LEECHES ON SALMON FRY AND EGGS

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A HEAVY INFESTATION OF FRESH-WATER LEECHES on eggs and fry of pink salmon (Oncorhynchus gorbuscha) recently occurred at the Hood Canal State Salmon Hatchery of the Washington State Department of Fisheries, located at Hoodsport, Washington. This station is supplied with both fresh and sea water, which can be delivered to the troughs and ponds in any desired combination. The fresh-water supply is drawn from the adjacent Finch Creek, which empties into Hood Canal at the hatchery site. Sea water is pumped from Hood Canal at a depth of 70 feet.

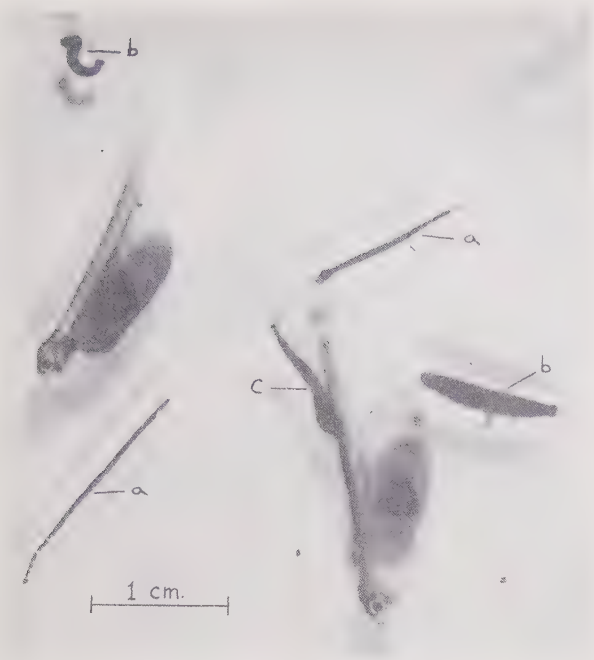
Appearance of the leeches was first noticed about November 1, 1953, in baskets and trays of pink salmon fry and eggs hatching in troughs supplied with fresh water. As trays were removed from the stacks, large numbers of very small leeches were observed, sometimes two or more on a single fry or egg. In an ungorged and relaxed condition, these parasites measured approximately 1-1/2 to 2 centimeters in length and less than 1 millimeter in breadth.

As nearly as could be determined, little, if any, damage occurred to the eggs as a result of attachment by one or more leeches. Once attached to the fry, however, the leeches quickly became gorged with blood, and the fry so attacked invariably died. Losses to sac fry were estimated to be as high as 25 percent in some baskets. Favored points for attachment were the head, eyes, and caudal peduncle. Large numbers of leeches, both gorged and ungorged, could be found throughout the fresh-water system, where the parasites attached themselves to the bottom and sides of the troughs and could be found massed along the top edges of baffle plates and screens.

At its mouth, Finch Creek is racked into a holding and trapping area for adult salmon migrants. Prior to the influx of leeches at the hatchery, adult chum salmon (O. keta) had been passed above the rack for spawning in the upper reaches of the creek. There is also a resident population of smaller fishes in the stream. A survey of spawned chum salmon carcasses in the creek revealed the presence of large numbers of gorged leeches attached to the gills.

Samples of leeches taken from both the salmon fry in the hatchery troughs and the adult salmon in the creek were tentatively identified as Piscicola salmositica by Dr. James E. Lynch, School of Fisheries, University of Washington. This classification of the leech was later confirmed by Dr. Marvin C. Meyer, Department of Zoology, University of Maine, who first described the species. This species of leech has been reported previously on salmon and steelhead trout from streams in Washington, Oregon, and California. Heavy leech infestations of other fresh-water fishes have been reported by Haderlie (1953) and Meyer (1946a, 1946b, 1949).

None of the chemicals (formalin, roccal, pyridylmercuric acetate) commonly employed by the Department for the treatment and control of bacterial and parasitic diseases showed any effect on the leeches. It was found, however, that they were particularly sensitive to undiluted sea water having a salinity of at least 28 parts



Pink salmon fry and leeches (Piscicola salmositica): (a) ungorged, relaxed leeches; (b) gorged leeches; (c) attached, gorged leech.

(Courtesy of Raymond W. Guenther, Fish and Wildlife Service, Seattle, Wash.)

per thousand. Small sample lots of pink salmon eggs and fry, with and without leeches attached, were separated in shallow troughs. The fresh water was shut off and the sea water turned in. Samples of each group were removed from the sea water and returned to fresh water at 15-minute intervals, the maximum exposure to sea water being 1 hour.

After a 1-hour exposure, all leeches died. Those exposed for shorter periods were not killed, though they showed increasing distress and their engorged blood was noticeably darkened.

No apparent damage to eggs or fry resulted from such treatment. On contact with sea water, sac fry became subdued in movement; they regained normal activity as soon as they were returned to fresh water. Test lots were observed several days after exposure, and no undue mortalities developed except in fry that previously had leeches attached. All these fish died.

A 1-hour treatment with sea water was given to all pink fry and eggs on hand after these tests, and no undue loss directly attributable to the exposure to sea water was observed. Reinfection by additional parasites that came down in the water supply occurred within a few hours after treatment.

Although treatment with sea water is a relatively simple procedure at this station, some screening device capable of removing the leeches from the water supply seemed desirable. Socks of plankton netting of various mesh sizes were fastened over the water inlets, and it was found that a weave of 125 meshes per inch prevented passage of the leeches and carried the normal flow of water. Clogging of the netting with fine debris presents a serious problem.

In addition to the pink salmon fry and eggs in the hatchery troughs, there were 3- to 4-inch silver salmon (O. kisutch) fingerlings weighing approximately 50 to the pound in outside rearing ponds. The water supply came from the same source as that used for the hatchery troughs. A random sample of these fish showed none with leeches attached. Losses in these stocks were very low during the period when leeches were observed in the system. It is therefore believed that leeches offer no serious threat to the well-being of fish of this size. Release of these fish to salt water will certainly remove any leeches that may be attached.

Hatchery personnel have reported that numbers of leeches were noticed under similar circumstances during the winter of 1952-53, when the station was first put in operation, but the incidence was not considered serious at that time. Heavy infestations of leeches have been reported on adult salmon migrants in other streams adjacent to Finch Creek during the past migration season. Indications were that, in some instances, the infestation with leeches was so heavy that the fish died prior to the deposition of their eggs. No investigation was made of the incidence of leeches among salmon fry in the gravel of these streams, but it could conceivably be heavy.

Should an equally heavy leech infestation occur next season at the Hoodsport Hatchery, it is anticipated that some sort of sand filter should be incorporated into the fresh-water line supplying the hatchery troughs. Use of the filter would be necessary only while eggs and fry were being held at the station.

Literature Cited

Haderlie, E. C.

1953. Parasites of the fresh-water fishes of northern California. Univ. Calif. Publ. Zool. 57 (5): 303-440.

Meyer, M. C.

1946a. Further notes on the leeches (Piscicolidae) living on fresh-water fishes of North America. Trans. Am. Micro. Soc. 65: 237-249.

1946b. A new leech, Piscicola salmositica n. sp. (Piscicolidae), from steelhead trout (Salmo gairdneri gairdneri Richardson, 1838). J. Parasitol. 32 (5): 467-476.

1949. On the parasitism of the leech, Piscicola salmositica Meyer, 1946. J. Parasitol. 35 (2): 215.

EFFECT OF STARVATION UPON BROOK AND RAINBOW TROUT

A study to determine the effect of long periods of starvation on brook and rainbow trout has recently been completed by Dr. A. M. Phillips, Jr., at the Trout Nutrition Laboratory (U. S. Fish and Wildlife Service), Cortland, New York.

Brook and rainbow trout were held in hatchery troughs at two water temperatures, 47° and 51° F. The water level was reduced to about half the usual depth in order to increase the rate of flow. The control fish of both species were given the normal food allowance; the other fish were given no food. Losses were recorded daily, and the fish were weighed at 2-week intervals. At the start of the experiment, brook trout and rainbow trout averaged 10.3 grams in weight.

At the end of 14 weeks the livers of the brook trout were removed and analyzed for riboflavin, pantothenic acid, biotin, niacin, water, fat, and blood glucose. The livers of the starved trout showed riboflavin, biotin, and pantothenic acid at levels considerably lower than those in the control fish. Apparently little of the reserve niacin was used during the starvation period, as the livers showed an increased niacin content. Fat content in the livers of starved trout was about half that of the control fish. The blood glucose was also lower in the starved trout than in the control fish, perhaps representing the lowest level reached in starvation prior to death.

During the 14-week period the average weight of the starved brook trout held in both water temperatures dropped from 10.3 to 6.2 grams, while the weight of the control fish increased to 18.5 grams each in the cold water and to 75 grams each in the warmer water. No excessive losses developed during this period, but at both temperatures the starved brook trout were listless, thin, and barely able to keep themselves from being washed onto the tail screen.

So few rainbow trout were available at the end of a 12-week period of starvation that blood sugar and fat analyses of the livers could not be made. The vitamin analyses for these fish, however, were approximately the same as those reported for the brook trout.

For the rainbow trout, as for the brook trout, a progressive loss of weight was recorded during the period of starvation. At the end of 12 weeks, the starved rainbow trout held in the cold water averaged 3.7 grams in weight and those that had been held in the warmer water averaged 4.2 grams.

RELATIVE SURVIVAL OF HATCHERY AND WILD TROUT

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SEVERAL WORKERS have shown that the survival of hatchery fingerlings in streams is lower than that of comparable wild fingerlings. Schuck (1948) presents a comprehensive survey of the whole problem, and he and others have hypothesized that the debilitating influence of hatchery life could be the cause of this. Certain tissues of hatchery-reared trout have been shown to be abnormal in comparison with the tissues of wild trout. The lack of exercise in the hatchery environment has also been cited as a possible cause of lowered vitality and consequent reduced survival. Schuck, in the survey cited, summarizes certain tests made in Crystal Creek, New York, and reaches the following conclusion:

> In contrast with the survival of the planting of hatchery trout in September 1941 (survival of 6.3 percent to September 1942), 23.0 percent of the wild fingerling brown trout survived from September 1941 to September 1942. The difference between 6.3 and 23.0 percent is statistically significant.

There is no evidence to indicate that hatchery life is not partially responsible for the relatively lower survival. However, there are two other factors which may have some bearing on survival, and it is evident that the relative importance of these factors should be studied.

Investigations have ordinarily begun with trout which are at least of the fingerling stage. The hatchery-produced fingerlings have not been subjected to the severe "culling" to which the wild fish already have been subjected. Hatching practices are aimed at reducing the mortality of the eggs, fry, and "pre-planting" fingerlings to a minimum. It is not unreasonable to assume that many eggs and fry are prevented from dying because of the care given them in the hatchery. In streams and lakes where normal predation exists, part of the emerging fry are lost through many causes. At the stage when wild fry are emerging from the gravel of the redds, the hatchery fry are given the greatest care: all predators are rigidly excluded, no swift currents sweep the fry into an unfriendly environment, and food is presented to them so that no starvation or weakness is likely. Grossly abnormal hatchery fry can live and grow and eventually reach plantable size. It is probable that even slightly abnormal fry and small fingerlings are lost in the wild through the many processes which make up the "survival of the fittest."

Thus, by the time the young trout are of plantable size, the hatchery lot may contain many abnormal individuals; while the general health of the wild lot will be better because it is relatively free of these abnormal fingerlings. All this difference might exist without regard to the hatchery diet or the lack of exercise in the hatchery trough. If, then, our comparison of the two lots begins with more or less advanced fingerlings, it could be that we would have some difference in survival after liberation, regardless of hatchery feeding or lack of exercise. Our test thus would not actually be a valid one--at least, not from the customary point of view. We would be introducing

variables which would make it very difficult for us to "pin down" the cause of the differential survival.

Considerable work has been done on mortality rates in early life-history stages of different species of Pacific salmon (Barnaby 1944; Brett and McConnell 1950; Foerster 1938; Neave 1949; Pritchard 1948; Wales, unpublished [1]).

The work of these investigators has shown that, from the time the eggs are deposited by the fish in the stream gravel until the fingerlings are about a month old and commencing their migration, the mortality may be roughly 90 percent. If, on the other hand, these same eggs had been spawned artificially and reared in a hatchery to early fingerling stage, the total mortality would be approximately 15 percent. From this we may conclude that Nature is far less hospitable to young fish than the average hatcheryman.

Since the time of Darwin it has been widely conceded that the heavy loss of young animals and plants is largely beneficial to the species. Most--though, of course, not all--of the young fish which are lost are in some way less perfectly adapted to their environment than the fish which survive. The tendency is for the surviving fingerlings to be the stronger, more vigorous ones. The further this "culling" process goes, the better the average survival ability of the remaining individuals. Conversely, if the mortality is low--as in a well-operated hatchery--there will be many "abnormal" individuals which survive, and the vitality of the average fish will be lower than in the wild, naturally spawned group.

If we assume that this general line of reasoning is correct, then it is apparent that fingerlings which may be released from a hatchery are not entirely comparable to their wild brothers and sisters. It is perfectly logical to suppose that the mortality after planting will be greater in the hatchery fish than in the wild fish, simply because the hatcheryman has been so kind to his charges. The hatchery fish may suffer considerably higher loss because the hatcherymen have actually given them better care than these same fish would have had in nature. This point is entirely separate from the harmful effect that a poor hatchery diet may have. There is no question about the effect of an unbalanced hatchery diet, or the fact that hatchery fish are often fed too much, or are kept under conditions which do not improve their health. All these things are widely recognized as being harmful. In these respects the hatcheryman is not developing a strong, vigorous fingerling, capable of caring for itself after liberation. The abnormal individuals are not being weeded out, and these, we may presume, will be the first to go when planted in natural waters.

Thus we see that when we mark a group of hatchery fingerlings and liberate them in a lake or stream, the mortality is surprisingly high. My contention is that our hatchery practices are, in certain respects, so very good that survival after planting is bound to be low. There may be nothing we can do about this. Even though the hatchery care pampers the weak individuals, Nature will quickly weed them out; the end result will be similar to the mortality rate in naturally spawned fish.

We all have heard the uninitiated speak with alarm about the low survival among planted fingerlings. The survival is low, but not entirely because of poor hatchery care. As pointed out earlier in this paper, we know that in many salmon populations the normal loss is 90 percent from the deposited-egg to young-fingerling stage. We do not have equally good figures on wild trout populations. It would be necessary to determine the number of spawning females in a stream and the total number of eggs they deposit, then determine the percentage of these eggs which hatch, and eventually reach the angler's creel. Such figures could be compared directly with figures on hatchery-reared fish, and then we would be in a position to tell whether our hatchery methods are inadequate.

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[1] Wales, J. H., 1951: Efficiency of king salmon (Oncorhynchus tshawytscha) spawning in Fall Creek, Siskiyou County, California.

Strains of Trout

Even though our hatchery technique might be perfected so that the planted fish would be as well able to take care of themselves as comparable wild fish, still we would have the problem of the suitability of the fish to the particular water where it was planted. In some waters the particular species and strain of trout might be able to survive comparatively well; but we have some reason to believe that, when planted in other waters having different characteristics, these same fish might be unable to survive. We have long been aware that brown trout that are planted in some streams live and become the dominant trout in those streams, but brown trout do not survive in other streams that are apparently quite similar. This same thing applies to all other species of trout and to fish generally. As I say, these peculiarities have long been known and accepted, but the possibility of having different strains of the same species show different adaptabilities is less widely recognized. We have only recently acquired enough experience to be able to distinguish "rainbow streams" from "brown trout streams" and "eastern brook streams," but now we may well be confronted with the need of choosing the best strain of rainbow or brook or brown trout to be stocked in each type of lake or stream. This may not be a difficult thing to do after we have accumulated more information, and the returns to the angler may be greatly improved thereby.

Literature Cited

Barnaby, J. T.
1944. Fluctuations in abundance of red salmon, Oncorhynchus nerka (Walbaum), of the Karluk River, Alaska. U. S. Fish and Wildl. Serv. 50, Fish. Bull. 39: 237-295.

Brett, J. R., and J. A. McConnell.
1950. Lakelse Lake sockeye survival. Jour. Fish. Res. Bd. Can. 8 (2): 103-110.

Foerster, R. E.
1938. An investigation of the relative efficiencies of natural and artificial propagation of sockeye salmon (Oncorhynchus nerka) at Cultus Lake, British Columbia. Jour. Fish. Res. Bd. Can. 4 (3): 151-161.

Neave, Ferris.
1949. Game fish populations of the Cowichan River. Fish. Res. Bd. Can., Bull. 84, 32 p., illus.

Pritchard, A. L.
1948. Efficiency of natural propagation of the pink salmon (Oncorhynchus gorbuscha) in McClinton Creek, Masset Inlet, B. C. Jour. Fish. Res. Bd. Can. 7 (5): 224-236.

Schuck, H. O.
1948. Survival of hatchery trout in streams and possible methods of improving the quality of hatchery trout. Prog. Fish-Cult. 10: 3-14.

Fishermen are much interested in the possibility of securing increased catches of tuna by attracting the fish with chemical preparations.

Personnel under the direction of the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service and biologists of the University of Hawaii have completed an extensive series of tank and pond trials designed to determine the reactions of the tuna to various chemical attractants.

Definite feeding reactions have been secured by introducing a clear extract from tuna flesh into ponds where tuna were being held. Though the pond tests have been successful, much more work must be done before a suitable attractant can be made available for use as a bait substitute at sea.

THE ALEWIFE IN FRESH WATER

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THE ALEWIFE, Pomolobus pseudoharengus (Wilson), an essentially marine clupeid, is found in Lakes Ontario, Erie, Huron, and Michigan, in a few small lakes in the Province of Ontario, and in several lakes in the State of New York. This fish has been known to be well established in Lakes Seneca and Cayuga of New York State since 1868 (Smith 1892) and in Lake Ontario since 1883 (Pritchard 1929).

Many theories have been advanced to account for the presence of alewives in fresh water where they are not known definitely to have been introduced or to have invaded in recent years. Bean (1884) suggested that they were introduced by mistake when shad, Alosa sapidissima, were being planted in New York lakes. Smith (1892) dismissed the theory of accidental introduction because alewives were known to exist in Lakes Seneca and Cayuga of New York before the planting of shad began. He suggested two additional modes of entry: a circuitous route of migration to Lake Ontario by means of certain lakes, canals, and rivers in the State of New York; and an ascent of the St. Lawrence River. Radforth (1944) has presented the most recent and acceptable theory for the presence of the alewife in Lake Ontario: "... because the invasion of the Champlain Sea is held responsible for the occurrence of other marine species such as the smelt and shad in certain eastern waters, it is not improbable that the presence of the alewife in Lake Ontario may also be attributed to the marine invasions." Alewives are also in the Rideau Canal system and Gananoque River system, which empty into eastern Lake Ontario. Toner (1934) offered two suggestions for their presence there: that they may have ascended through the numerous canal locks; or that they may be native, having established themselves at a time when Lake Ontario was much higher and covered the two systems. A survey in 1951 showed that barriers now prevent the alewife of Lake Ontario from ascending the two systems.

The establishment of the alewife in fresh water has been highly successful. This success is not limited to a specific fresh-water habitat, such as an oligotrophic lake. Odell (1934) reported that the alewife "thrives in Ballston Lake and Round Lake in New York State. Round Lake is only 29 feet deep and is warm throughout. Besides that the oxygen conditions on the bottom are very poor. Ballston Lake has deep water, 116 feet, and a thermocline. But there is practically no oxygen in the deeper portions and the deepest portions contain bog water."

The greatest obstacle to the success of the alewife in fresh water is found in its large annual mortality. Regardless of the mortality, the alewife is successful. Its ability to succeed lies in the following conditions:

1. Earlier sexual maturity in fresh water.[1/] The fresh-water alewife matures approximately 1 year earlier than the marine alewife. Thus, the fresh-water alewife may spawn at least once and possibly

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1/ Data forming the basis of this statement are to be published in the near future.

twice before the marine alewife. This is somewhat offset by a loss of fecundity. The fresh-water alewife produces 10,000 to 12,000 eggs at a standard length of 145 millimeters (Odell 1934), and the marine alewife an estimated 60,000 to 100,000 eggs (Belding 1921) at the larger size at which it matures. But, perhaps, better survival of the fresh-water alewife results from the shortening of time between hatching and subsequent sexual maturity.

2. Availability of spawning sites. Depletion of the marine alewife is evident throughout the Atlantic coast, but especially in New England. The lack of fishways over dams has been considered one of the chief reasons for this depletion. Prevention of ascent extremely limits the spawning sites of the marine alewife but not those of the fresh-water alewife, as the latter already inhabits the sites (headwater lakes) sought by the marine alewife.

3. Lack of upstream migration. The ascent of streams concentrates the marine alewife so that commercial fishing is effective. The subsequent descent takes its toll as well. Rounsefell and Stringer (1943) noted that numerous marine alewives die during the descent of streams to the sea. In contrast, no extensive ascents similar to those made by the marine alewife were noted in the life history of the Lake Ontario alewife, nor have any been reported in publications concerning the fresh-water alewife in other lakes.

4. Lack of commercial fishing pressure. The marine alewife is an important commercial species, yielding about 30 million pounds annually to commercial fishermen along the Atlantic coast. In contrast, the comparatively stunted fresh-water alewife is regarded as a nuisance and has no direct commercial value.

At present the alewife is spreading through the remainder of the Great Lakes. Dymond (1932) reported that the alewife was in Lake Erie in 1931, and Van Oosten (1935) reported its presence in Lake Huron in 1935. Recently catches of individual specimens were made for the first time in Lake Michigan.[2/] Some measure of the swiftness of their establishment in Lake Erie is available. On December 13, 1952, the Toronto Globe and Mail carried the following report: "Tiny shad were schooling in such numbers in the fishing waters off Port Stanley today that gill net fishermen were lifting them by the tons in their nets ... Tug crews today, through their short wave communicating systems, were reporting great schools of shad eight to twelve miles off Port Stanley." The "tiny shad" referred to above are alewives. In salt water the alewife is known as the alewife, gaspereau, or branch herring; but in fresh water the fish is often called the shad or saw-belly shad.

The distribution of the alewife throughout all the Great Lakes in future seems probable. The fact that first records have occurred after high-water conditions in the lakes (1929-30 and 1943-48) suggests that the resultant increased current and high levels in the connecting canals and rivers might have served as a stimulus to the anadromous habits of the alewife.

Literature Cited

Anonymous.
1952. Schools of shad plague fishermen. Toronto Globe and Mail (Dec. 13).

Bean, T. H.
1884. On the occurrence of branch alewife in certain lakes of New York. The Fisheries and Fishery Industries of the United States, by G. B. Goode, Sec. 1: 588-593.

Belding, D. L.
1921. A report upon the alewife fisheries of Massachusetts. Mass. Dept. Cons., Div. Fish & Game: 1-135.

[2/] Personal communications: T. L. Wirth, March 12, 1952; Ralph Hile, May 9, 1952.

Dymond, J. R.
1932. Records of the alewife and steelhead (rainbow) trout from Lake Erie. Copeia 1932 (1): 32.

Odell, T. T.
1934. The life history and ecological relationships of alewife (Pomolobus pseudoharengus) in Seneca Lake, New York. Trans. Am. Fish. Soc. 64: 118-124.

Pritchard, A. L.
1929. Alewife (Pomolobus pseudoharengus) in Lake Ontario. U. Toronto Studies, Biol. Ser. 33: 37-54. (Pub. Ont. Fish. Res. Lab. 38).

Radforth, Isobel.
1944. Some considerations on the distribution of fishes in Ontario. Contrs. Roy. Ont. Mus. Zool. 25: 1-116.

Rounsefell, G. A., and Louis Stringer.
1945. Restoration and management of the New England alewife fisheries with special reference to Maine. Trans. Am. Fish. Soc. 73 (1943): 394-424.

Smith, H. M.
1892. Report on the investigation of the fisheries of Lake Ontario. Bull. U. S. Fish. Comm., 1890, 10: 177-215.

Toner, G. C.
1934. Notes on the alewife. Can. Field-Nat. 48 (3): 51-52.

Van Oosten, John.
1935. First record of the alewife, Pomolobus pseudoharengus, for the State of Michigan. Copeia 1935 (4): 194-195.

REPRODUCTION OF FISH SUBJECTED TO ELECTRIC CURRENT

The possibility that fish might become sterile as a result of being subjected to electric current has interested many fishery biologists and fish culturists. As part of a fishery-management and research program on strip-mine impoundments, sponsored by the Truax-Traer Coal Company of Fiatt, Illinois, David E. Elder began to study the effect of electrofishing gear upon the reproductive capacity of the largemouth bass (Micropterus salmoides).

As described by Mr. Elder, the plant was a 2,500-watt 230-volt alternating-current unit. The electrode system was formed by 2 plates of aluminum wrapped around 2 boards that were 8 feet long. These electrodes were mounted about 10 feet in front of the boat and were about 6 feet apart.

"On July 2, 1952," writes Mr. Elder, "8 largemouth bass, their total lengths ranging from 10 to 14 inches, were completely stunned by the electric current and were collected with dip nets. The bass were transported to a spawning pond that contained no other fish. All specimens had completely recovered by the time they were released; they suffered no apparent harm from the electric current or from the handling.

"On September 13-14, 1953, this pond was drained and the fish were removed. In addition to the 8 brood bass, there were 4,266 largemouths that were 2 to 8 inches in total length. Approximately 96 percent of these were less than 5 inches in total length, and approximately 4 percent were 5 to 8 inches in total length. The brood bass were 12 to 15 inches in total length. All fish removed were in good condition."

Mr. Elder concludes that although this investigation should be repeated with other species in addition to the largemouth bass in order to obtain more conclusive data, in this particular case the fish were definitely not made sterile by the electric current.

PRELIMINARY EXPERIMENT ON FISH CULTURE IN BRACKISH-WATER PONDS

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BRACKISH-WATER POND CULTURE has been conducted on a commercial scale for generations in many Asiatic countries. Perhaps the most widely known Asiatic pond fishery is the Philippine bangos industry. As Carbine pointed out (1948), the cultural system in use in the Philippines today was not developed through systematic research but has evolved to its present status through centuries of trial and error. Although very few exact production records have appeared in the literature, it appears that 300 pounds per acre is the approximate average production of bangos in Philippine ponds. There are, however, persistent claims in some areas to unbelievable production figures. Most of these figures seem to be estimates made by fish farmers instead of scientific records kept by trained personnel.

These possibly questionable claims have served to stimulate the imagination of American pond culturists; for a number of years speculation as to the feasibility of rearing marine fish commercially in ponds in the United States has appeared from time to time in fishery literature. The striped mullet (Mugil cephalus L.) has been suggested almost unanimously by fishery workers because it is one of the major species reared in parts of the Orient and because of the biological niche in which it exists. The mullet feeds primarily upon vegetation and organic debris, the basis for all oceanic food. For this reason these basic materials go directly into the production of fish without the tremendous energy loss incurred when one organism is eaten by a larger one, which is in turn eaten by a still larger one, and so on. Actually, the selection of a pond species for culture in the United States must be based on criteria other than these.

Unlike the more populous countries, we must not only produce fish but also produce large fish that are palatable enough to command a relatively high market price. We must also be able to produce these fish in per-acre quantities that would be profitable in the face of high investments in ponds, labor, and other production costs. The mullet is ill-suited to these standards. Although this fish is considered very good when it is eaten fresh, it loses much in palatability when iced or frozen. This confines use of the fish almost entirely to the immediate coastal areas. And, though the mullet constitutes the bulk of the commercial fish catch in Florida waters, 10 cents a pound is considered a fair average of the prices that are paid to the fisherman (Broadhead 1953).

In July 1952, an experimental project in brackish-water pond culture was initiated at the Marineland Research Laboratory. As there was no domestic precedent for a program of this kind, it was considered desirable to know first the carrying capacity of estuarine waters of the area and the increase in carrying capacity that could be obtained through fertilization. Because it does feed at the bottom of the "food chain" and because the young were available in large numbers, the mullet was selected as the test animal

in spite of its inherent handicaps as a commercial pond species.

Experimental Units

Four 1/8-acre experimental ponds were excavated in the tidal marsh area adjacent to the Intracoastal Waterway at Marineland, Florida. The ponds were rectangular and had an average depth of 3.5 feet. Each pond was equipped with an inlet pipe to maintain the water level at the desired height. The pipes in three of the ponds (hereafter referred to as ponds 1, 3, and 4) were fitted with automatic storm-gate valves that allowed tidal water to enter the ponds at flood tide but prevented an efflux at ebb tide. The pipe in pond 2 was fitted with a standpipe that allowed both influx and efflux of water depending on the relative heights of the pond level and high tide. The water level in pond 2 was, in general, lower than that of the other ponds.

Periodic analyses for the dissolved oxygen, free carbon dioxide, pH, surface temperature, and salinity were made throughout the experiment. Dissolved oxygen and free carbon dioxide were determined for both the surface and the bottom waters in each pond. Salinity, pH, and temperature were determined only at the surface.

At no time did the chemistry of the pond water appear unfavorable for most estuarine fish. The dissolved oxygen content did not fall below 5.0 parts per million in either the surface or the bottom waters. Free carbon dioxide was absent except when extremely low salinities occurred. At these times free carbon dioxide was present in small amounts in the bottom waters. The range in pH for the experimental period was from 7.6 to 9.4, and the range in salinity was from 7.6 0/00 to 35.7 0/00. The lowest surface temperature recorded was 43° F.; the highest, 87° F.

Rearing Experiments

On December 31, 1952, each pond was stocked with 2,000 fingerling striped mullet per acre. The young mullet averaged 29.8 millimeters (total length) on this date.

Ponds 1 and 3 were fertilized with 7-9-0 commercial inorganic fertilizer at the rate of 200 pounds per acre per month. Each of these ponds received a total of 2,300 pounds of fertilizer per acre. Ponds 2 and 4 were unfertilized.

Fertilization resulted in a visible increase in the plankton in both fertilized ponds. Pond 2, which had a lower surface level than ponds 1 and 3, was situated between these two ponds. These conditions were conducive to a relatively high rate of seepage of fertilized water into pond 2, and that pond also sustained a very good bloom. Pond 4 never supported a visible plankton bloom.

As pond 2 was not considered representative of either fertilized or unfertilized ponds, it was drained July 8, 1953, and put in a feeding experiment. The remaining ponds were drained at the end of 11 months.

Results

Contamination of all ponds by species of fish other than the mullet occurred in spite of the precaution of placing two thicknesses of plastic window screen over each inlet pipe. These species included black drum, speckled trout, sheepshead, menhaden, killifish, and others. All are believed to have entered the ponds as larvae small enough to pass through the screens, as the ponds were treated with emulsifiable rotenone (3.0 parts per million) several weeks before being stocked. The screens were installed prior to the poisoning.

The production of fish in ponds 1, 3, and 4 is shown in the table. As pond 2 was drained before the experiment was terminated, that pond has not been included in the table for comparison with the other ponds. However, pond 2 produced 191.72 pounds of fish per acre in 27 weeks. This is roughly equal to the production in pond 3, a fertilized pond, in 11 months.

The unfertilized pond produced 154.4 pounds of fish per acre. The highest yield

	Pond 1 (Fertilized)	Pond 3 (Fertilized)	Pond 4 (Unfertilized)
Mullet--			
Pounds per acre	117.6	128.0	99.6
Number per acre	864	1,328	1,264
Average total length in mm.	174.8	164.6	143.7
Percentage mortality	57	34	37
Total fish--			
Pounds per acre	276.8	194.8	154.4
Pounds per acre due to fertilization	122.4	40.4	0.0

obtained by fertilization was 276.8 pounds per acre. The maximum increase due to fertilization was therefore 122.4 pounds per acre; the average increase was 81.4 pounds per acre. The maximum production of mullet was 128 pounds per acre, an increase of only 28.4 pounds due to fertilization. The average mortality of the mullet in all ponds was 42.6 percent. None of the fish produced approached a marketable size.

Discussion

It was fully recognized that, owing to the small number of experimental units, the results of the experiment by no means represented true averages of the production of fertilized and unfertilized brackish water. The results were considered conclusive in showing that the addition of inorganic fertilizer would not, even under the most favorable conditions, increase the production of mullet or the other species involved enough to sustain a commercial pond fishery. Although it is probable that fish of a marketable size could be produced by stocking with fewer individuals per acre, lower total poundages would be most likely to result. It is also probable that increased total poundages of fish would result from increased stocking rates; however, the total poundage would be composed of fish below a marketable size.

In progress at Marineland are further experiments on the selection, propagation, and rearing of species that could be produced profitably by the use of supplemental feeds. Owing to the low market value of the mullet, it is extremely doubtful that the fish could be produced as a major crop cheaply enough by this method to sell at a profit. However, the possibility exists that the mullet could very well be utilized as a supplement to a major crop of another species.

Literature Cited

Broadhead, G. C.
1953. Investigations of the black mullet, Mugil cephalus, in northwest Florida. Tech. Bull., Fla. Sta. Board Cons., No. 7.

Carbine, W. F.
1948. Bangos culture in the Philippines. Prog. Fish. Cult. 10 (4): 187-197.

Material for listing in the Clearing House of THE PROGRESSIVE FISH-CULTURIST should be directed to the attention of the Editors with any information deemed likely to be of assistance or value to the Editors or to the readers of this periodical.

FEEDING HABITS OF THE LARGEMOUTH BASS AS REVEALED BY A GASTROSCOPE

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WE STILL HAVE MUCH TO LEARN about the relationship between the largemouth bass and the various fishes upon which the bass feeds. Many of the existent studies of the food habits of this species have been adversely affected by the method of capture. Some methods of capture permit the captured fish to gorge themselves with the smaller fish which might be held in the trapping device; still other methods permit digestion of the food materials prior to examination. Angling, which avoids the above-named evils, probably gives a biased sample because of the obvious disadvantage of taking only such fish as are feeding. A further difficulty in the study of bass food habits has been the necessity to sacrifice great numbers of larger bass. It is suggested, therefore, that a study based on collection by electrical means and examination of the stomach contents by the method described in the present work appears to avoid all the above-mentioned shortcomings of existing methods.

Method of Procedure

The fish for examination were taken by means of an electrical shocker using a generator that supplied 180-cycle 230-volt alternating current at 6.3 amperes. The electrodes were mounted on booms on the bow of a boat. In operation the boat was slowly propelled through the water by an outboard motor. At times the apparatus was operated along the shoreline and at times in a circle in open water. Any stunned bass that was more than 12 inches in length was dipped up. While holding the fish by its lower jaw, the examiner inserted a long metal cone--a gastroscope--of appropriate size into the bass' mouth, through the pharynx, and into the anterior end of the stomach. The funnel held the stomach open in such a manner that the major items of food in the stomach were easily discerned. A record was made of the stomach contents along with the length of the fish. A record was also made of such food fish as were in the stomach. The specimen was then released. For details on the gastroscope, see the figure.

To observe the variation in percentage of empty stomachs as associated with time of day, the Crab Orchard population was sampled around the clock. Also from the Crab Orchard data, analyses were made of the size of shad eaten and the efficiency of collecting as associated with sampling by day and by night.

To reveal the effect of the presence of different forage-fish populations on the feeding habits of the bass, four lakes were sampled. In two of these lakes, the gizzard shad was abundant; in the other two, the shad was either absent or very scarce. For each lake the principal fishes are given, along with a discussion of the feeding habits of the bass.

This study was sponsored by the Illinois Department of Conservation and Southern Illinois University.

Crab Orchard Lake

Crab Orchard Lake is an artificial impoundment in Williamson County. It covers an area of 6,579 surface acres. Its fish population is composed primarily of gizzard shad, bluegill, crappie, yellow bass, largemouth bass, and carp.[1/] Crab Orchard Lake was sampled once weekly for 24 hours, the work beginning May 13 and ending September 18, 1953. During this period, 552 bass from the lake were examined. Of the total sampled, more than 50 percent had empty stomachs, the greatest number of these occurring between the hours of 2 a.m. and 8 a.m. (table 1).

In the analysis of the relationship between time of day and effectiveness of the method of collection (electrical shocker), the catch was found to be fairly well distributed throughout the day and night (table 2).

Most of the gizzard shad eaten by the Crab Orchard largemouth bass were from 3 to 6 inches in length; however, specimens measuring 6 to 10 inches in length were taken by larger bass (table 3).

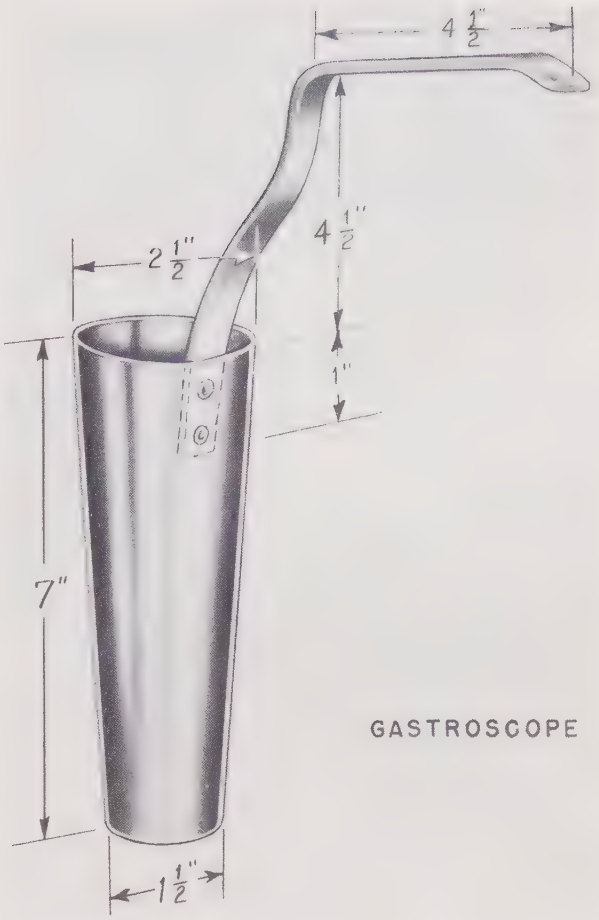

TABLE 1.--Percentages of largemouth bass with empty stomachs, arranged according to time of day

/Based on 552 specimens taken from Crab Orchard Lake./

Month	Percentage of empty stomachs			
	2 a.m. to 8 a.m.	8 a.m. to 2 p.m.	2 p.m. to 8 p.m.	8 p.m. to 2 a.m.
May	86	78	54	48
June	75	25	37	50
July	83	--	50	56
August	78	61	53	69
September	78	64	70	45

TABLE 2.--Comparison of captures of largemouth bass by electrical means at different times of day

/Based on 552 specimens taken from Crab Orchard Lake./

Month	Bass taken by shocking			
	2 a.m. to 8 a.m.	8 a.m. to 2 p.m.	2 p.m. to 8 p.m.	8 p.m. to 2 a.m.
May	14	18	47	40
June	11	8	18	8
July	19	0	5	35
August	49	31	88	75
September	19	22	17	28

Of the 552 bass taken, the stomachs of 337 were empty. In the bass stomachs that contained food, the items found were as follows:

[1/] Whitacre, M. A., 1952: The fishes of Crab Orchard Lake, Illinois. Fourteenth Midwest Wildlife Conf., Iowa State Cons. Comm., Des Moines, Iowa. Dec. 17-19, 1952. 41 pp. mimeographed.

Gizzard shad	63
Bluegill	11
Yellow bass	3
Crappie	2
Crayfish	2
Carp	1
Gambusia	1
Largemouth bass	1
Angleworm	1

Carbondale Reservoir

The Carbondale Reservoir is an artificial impoundment at Carbondale, Illinois. It covers approximately 50 acres. Its fish population consists primarily of gizzard shad, crappie, bluegill, and bass.

The reservoir population was sampled May 5 through May 12, 1953. The 27 bass stomachs containing food held the following items (listed with number of occurrences):

Gizzard shad	8
Largemouth bass	1
Bluegill	1
Crayfish	3
Algae	1
Unidentified	13

Christopher Reservoir

The Christopher Reservoir is an artificial impoundment at Christopher, Illinois. This reservoir covers about 30 acres. Its fish population is made up primarily of bluegill, crappie, and largemouth bass. So far as is known, no gizzard shad are present.

The stomachs of 14 bass were empty, but 12 contained the following items (listed here with number of occurrences):

Crayfish	6
Largemouth bass	1
Bluegill	1
Unidentified	3
Plant leaves	1

Flatt Lake

Flatt Lake is an artificial impoundment near Buckner, Illinois. Flatt Lake covers an area of about 3 acres. The fish population is made up primarily of crappie, bluegill, largemouth bass, and bullheads. So far as is known, no gizzard shad are present.

TABLE 3.--Size of gizzard shad compared with the size of the largemouth bass that had consumed the shad

/Based on 63 largemouth bass taken from Crab Orchard Lake./

Size of bass in pounds	Size of shad		
	1 to 3 inches	3 to 6 inches	6 to 10 inches
1 to 2	1	12	0
2 to 4	1	31	6
Over 4	0	13	3

The stomachs of 43 bass were empty, but 30 contained the following items (listed here with the number of occurrences):

Bluegills	8
Beetles	1
Plant leaves	1
Unidentified	20

Discussion

The high percentage of empty stomachs occurring day and night indicates low vulnerability of the prey species. The fairly even distribution of full stomachs is rather surprising, because such a condition indicates that feeding is fairly well dispersed throughout the day and night.

The high percentage of shad in the bass diet may indicate either greater relative availability, vulnerability, or palatability of this species. But regardless of which is indicated, the fact remains that, where present, the shad is heavily utilized by the largemouth bass.

In conclusion, the writer wishes to point out that he considers electrical sampling combined with gastroscopic examination the ideal method of studying the feeding habits of bass. There is no reason why this method cannot also be used on many other fish species.

Acknowledgment

The writer wishes to express appreciation to Dr. William M. Lewis, under whose direction this study was conducted.

NEW METHOD OF ARTIFICIALLY PLANTING SALMON EGGS

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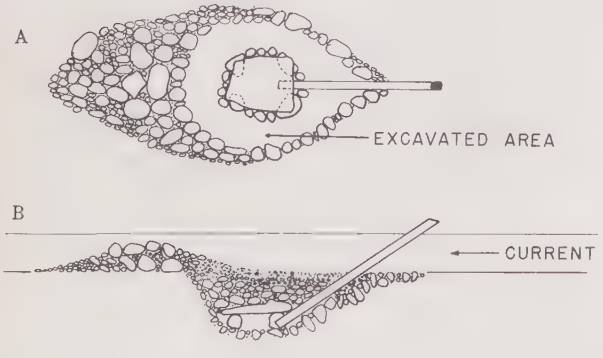
THE PROBLEM OF INTRODUCING SALMON into watershed areas barren of the species has been mastered in most fishery organizations by means of hatcheries and fry or fingerling plants. The Alaska Department of Fisheries, in lieu of hatchery facilities and standard methods of transportation, has made extensive use of either newly fertilized eggs or eyed eggs for such introductions.

For maximum results the eggs must be placed in the gravel of selected stretches of stream bed. Minimum requirements, as in the case of natural redds, are adequate subsurface percolation of water, protection from freezing during winter low-flow periods, and protection from natural predators such as cottoids or trout. The necessity of portaging equipment has ruled out heavy or cumbersome devices such as Harrison planting boxes and digging cylinders and has resulted in a method of introducing eggs into an artificial redd made with only simple, easily portable tools.



The artificial nest. A--Top view of the nest, with the slab in place. B--Lateral cross section of nest.

Nests resembling natural salmon redds are dug in selected riffles of a stream to be planted. These excavations are roughly circular, about 3 to 4 feet in diameter, and 12 to 18 inches deep. All material removed is placed on the downstream edge to form a semicircular dike below the nest. A large stone slab is placed over the bottom of the nest and supported at the corners by stones 6 to 8 inches in diameter. Large stones are loosely placed about the margins of the slab, resulting in the formation of an enclosed "room" to be used as the incubator. Next a 5-foot section of metal drainpipe is placed so that one end enters the "room" and the other angles upstream and a few inches above the surface of the water. The slab is then completely covered, first with coarse stones and last with fine gravel containing some sand.

Frequently the gravel beds of a barren stream are hard-packed and difficult to penetrate with shovels. A charge containing one or two sticks of 40-percent dynamite placed under a flat stone will loosen the gravel sufficiently to facilitate nest excavation.

After the nest is prepared, several gallons of water are poured down the tube to assure free passage and distribution of the eggs. Then the eggs are poured in water down the tube and flushed with water at intervals. Properly constructed nests will contain approximately 1 gallon of eggs. During hot weather the completed nests are treated with malachite green to

retard the formation of fungus. The tube is then withdrawn, as the operation has been completed.

Artificial redds, as described, are relatively simple and easy to prepare. A crew of three men has planted more than a million red salmon eggs in 12 hours. Working under severe winter conditions, a crew of five planted a hundred thousand eyed king salmon eggs in 3 hours.

Observations made after 2 years of planting by this method indicate excellent survival of the eggs to fry and to fingerling stages. A tributary stream of Frazer Lake, Kodiak Island, was planted with green eggs in August 1951. Sampling with a seine at the mouth of this stream in June 1952 resulted in the recovery of red salmon fry. A plant of green eggs, made in July 1952, was examined in December of that same year. Red salmon alevins were recovered from the nest, and no dead larvae or eggs were found. The operation of a downstream migrant trap at the outlet of a planted lake on Afognak Island gave evidence of survival and exceptional growth to the yearling migrant stage.

A method of artificially introducing salmon eggs into nonproducing watersheds, requiring only shovels and light drainpipe as tools, makes the operation feasible under the most adverse conditions of transportation and terrain. Subsequent observations have indicated good survival from such plants, although no serious statistical comparisons have been attempted.

Planting the eggs.

FLUORESCENT FISH

Do you minnow dealers or members of fair committees wish to display one or two species of live fish in an unusually spectacular manner?

Leon D. Johnson, aquatic biologist with the Wisconsin Conservation Department, reports that he and Louis Posekany discovered some years ago that an intraperitoneal injection of a water solution of a fluorescein dye gave the entire fish a green fluorescence that lasted about a week. This effect was interesting but, because it did not provide a means of marking the fish permanently, was not useful in fish management. However, the dye was nontoxic and therefore was used occasionally in the preparation of aquarian displays of crappies and bluegills. These attracted considerable attention.

More recently news of this process has been released to minnow dealers, and it is expected that aquaria equipped with ultraviolet lights and the shining fish will have excellent advertising value.

North America's 10 largest lakes have a combined area of about 127,000 square miles.

CONVERTING CARBOYS INTO JARS AND AQUARIA

Oliver B. Cope
U. S. Fish and Wildlife Service
Logan, Utah

OPEN-TOP GLASS VESSELS have long been used for experimental tanks, aquaria, culture jars, and other purposes in laboratories, aquarium exhibit rooms, private aquaria, and experimental establishments. Present costs of most containers from scientific-supply houses, however, make it almost imperative that less expensive glass vessels be secured when large numbers of exhibits or experimental tanks are needed. As a 3-gallon glass battery jar now retails for almost $5 and a 5-gallon rectangular museum jar or cylindrical specimen jar costs more than $9, many laboratory workers and aquariists find it advantageous to convert 5- and 10-gallon glass carboys into jars and aquaria. A 5-gallon carboy may cost from 25 cents to $1.75, depending on whether it is second-hand or new; this initial cost is almost the only expense if ordinary chemistry laboratory facilities are available; and the resulting container, though it may be of glass inferior to that of new aquaria or jars, will be adequate for most needs.

The Hot-Wire Method

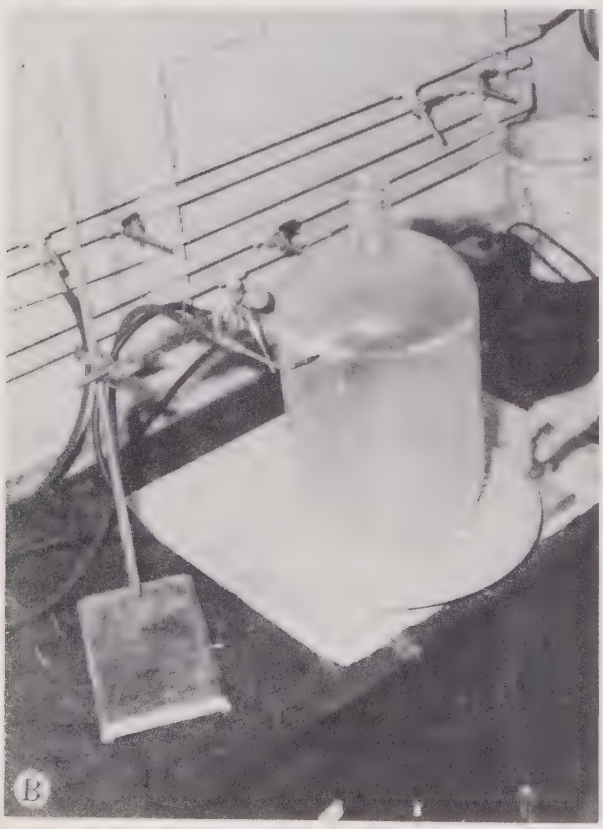
The hot-wire method of removing the top of a carboy utilizes a resistance wire heated electrically while in contact with the carboy, around the circumference where the fracture of the glass is desired. Nichrome resistance wire, B & S gauge 18 to 24 (resistance per thousand feet, 1.70 to 2.30 ohms), works well. A variable transformer should be used to give proper voltage for the particular size of wire used. The author has had good results from nichrome wire at 24 volts a.c.

With a sharp file or glass cutter, four or five scratches are made around the carboy along the proposed line of fracture. Next, one or two turns of the wire are wrapped tightly around the carboy at the level of the scratches, the wire is held tightly with an insulated clamp serving as the electrical leads, and the electric current is turned on. A low initial current should be used in trial attempts; it can be increased as necessary. (See figure.)

Care must be taken to avoid short circuits where the wire is attached to the clamp. The wire should heat and glow red-hot. A half minute or more of heating should make the glass hot enough along the line where the break is to occur. A cloth moistened with cool water is then touched to the wire and glass at any point around the loop. If this technique is properly followed, the carboy will break cleanly in contact with the wire. The current is then turned off, the top of the carboy is lifted off, the wire is removed, and the only further step is to smooth the new jar's sharp edge. This is smoothed by scraping with a file and then emery cloth. Fire polishing is not feasible because of the low quality of the glass ordinarily used in carboys.

The Flame Method

This method of removing the top of a carboy requires a hot oxygen-acetylene flame and a turntable. A turntable may be made with a thrust bearing (or some other type of ball or roller bearing) and one or two pieces of 3/8- to 1/2-inch plywood. The fixed part of the bearing is attached to a wooden base on a table, and the moving



part to a round piece of plywood 12 to 18 inches in diameter. The revolving plywood is adjusted to rotate smoothly in a balanced state.

The desired line of fracture is marked by setting the carboy in the exact center of the turntable, rotating it manually, and holding a wax pencil against the turning carboy. When this circumference has been scratched with a sharp file or glass cutter, as in the hot-wire method, the carboy is ready for the flame. The torch is clamped to a ringstand, away from the carboy, and the flame lit and adjusted to its greatest heat. The best results are obtained with a blue flame cone 1/4 to 1/2 inch long and a pin-point apex. With the flame at maximum heat, the carboy on the turntable is slowly rotated and the ringstand with the torch is slowly moved forward until the tip of the inner blue flame touches the carboy. (See figure.) The turntable is rotated at a rate of 1/2 to 1 revolution per second until the fracture occurs. The "ping" of the fracture may come 20 seconds to 2 minutes after the flame is first applied. The flame is then withdrawn, the top of the carboy removed, and the remaining vessel will be ready for use when it has cooled and its edge has been smoothed.

Comments

It is recommended that goggles be worn by anyone using either method.

Both methods are reliable when used properly. The flame usually produces a neater fracture and perhaps is easier. On the other hand, the hot wire does not require a turntable. It would probably be sensible to use the hot wire when only a few carboys are to be converted, but to take an hour to make a turntable and use the flame when more vessels are needed.

Removal of a carboy top by:
(A) the hot-wire method.
(B) the flame method. The crack occurred just before the picture was taken, and the top has not yet been lifted off. Discoloration is due to dirt inside the carboy.

DIVIDENDS FROM RESEARCH

MANAGEMENT OF THE SOCKEYE SALMON OF THE FRASER RIVER

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The 90,000-square-mile Fraser River watershed in British Columbia has long been known as one of the greatest salmon-producing systems in the world. The principal species, the sockeye salmon (Oncorhynchus nerka), has contributed more than 300 million fish to the combined catch of the United States and Canada since recorded commercial fishing began late in the last century. Like many of the salmon fisheries of the Pacific Coast, the sockeye fishery maintained by the Fraser River has suffered greatly reduced catches in recent decades. The total catch in the 12-year period from 1933 to 1944 was only 35 percent of the total catch in the period from 1901 to 1912.

The continued decline of the stocks led eventually to concerted international action, and Canada and the United States ratified in 1937 a treaty establishing the International Pacific Salmon Fisheries Commission. The treaty charged the Commission with the protection, preservation, and extension of the sockeye-salmon fisheries of the Fraser River system and with providing by regulation an equal division of the catch between the fishermen of the two countries.

The international administration of the sockeye-salmon fishery dependent on the Fraser River watershed is based on what might best be termed the "three R's" of fishery management. These R's are as follows: Research--to determine causes of the decline in abundance of the species and to find methods of restoration; Regulation--to control fishing, to provide an escapement of the maximum reproductive efficiency, and to allow rebuilding of depleted races; Rehabilitation--to replace exterminated races and to restore access of the spawners to obstructed spawning streams and rearing lakes.

Research demonstrated that delay and blocking of the upstream migration of adult sockeye at Hell's Gate and elsewhere on the Fraser River were a major cause of the depletion of the once-great runs. At Hell's Gate dumped rock and a slide attendant on railway construction all but exterminated the escapement from the 1913 run. The 1913 run, the largest of all runs, had yielded a catch of approximately 30,000,000 sockeye and a pack of 2,400,000 cases of 48 pounds each. A program to remove slide material was vigorously conducted in 1914-15, but the Fraser sockeye entered a 32-year period of decline. Investigations made by the Commission revealed that sockeye runs had continued to be obstructed at certain water stages. The delayed and blocked fish lay quietly and obscurely in the turbid eddies for miles below Hell's Gate and eventually disappeared, unnoticed. No tagged sockeye that had been delayed more than 14 days below Hell's Gate was ever recovered on its spawning ground above Hell's Gate.

Construction of fishways at Hell's Gate and at two other natural points of hazard on the watershed has completely relieved the throttling effect of the obstructions.

Since 1946 the Commission has regulated the fishery in order to allow the maximum catches commensurate with the

restoration of depleted races. The regulations for each year are prepared on the basis of a great mass of biological data which indicate the regulatory requirements for the racial runs of that year. The total catch of sockeye since 1946 has been divided almost equally--49.1 percent of the catch for United States fishermen and 50.9 percent for Canada. The trend of depletion has been reversed, and catches and escapements alike are increasing.

The value of the 1951 catch exceeded the value of the catch in its parent year, 1947, by $8,232,000, and the pack for 1951 broke the pack record of the cycle back to 1903. The catch in 1952 showed an increase of $2,755,000 in value over the 1948 catch and broke the cycle pack record back to 1912. The catch in 1953 was the largest of its cycle in 36 years, contributing $7,000,000 more in canned salmon values than was produced in the preceding cycle. The total cost of the Commission's Fraser River enterprise during a 15-year period was repaid at least twice in the increased catches in the current year /1953/ alone.

The rehabilitation of vanished runs is proceeding slowly but positively. Diligent protection of any remnants of native stock and experimental transplants by various methods--using donor stocks that have been taken from matching environments--are the principles that guide the present attempts at restoration of the runs. Several races of sockeye whose spawning populations had been reduced to maximums of a few tens or hundreds of sockeye 12 years ago now have spawning populations that exceed one hundred thousand fish.

Much progress is being made in preserving and extending the stocks of sockeye salmon in the face of the increasing industrial development of the Fraser River basin. Vigorous increases in the catches and escapements of sockeye are of great value in maintaining a place for salmon in the economic expansion of the watershed.

BOG LAKES NOW PRODUCE RAINBOWS

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Through a fundamental study of bog waters, we have found a simple and inexpensive method that shows every promise of proving successful for turning small bog-lined "kettle" lakes into producers of rainbow trout and bass.

The method, developed in our field and laboratory studies, consists of the addition of lime to alkalize the lake water.

The hydrated lime reduces the brown coloration of the water in bog-fed lakes, allowing sunlight to penetrate into the deeper regions. This, in turn, permits heavier plant and algal growth. The lime also releases plant nutrient materials from the chemical bond in which they are held, making them available to the growing plants that are important in the food chain for trout.

The new lease on life given the plants by alkalization with lime results in an increase in the oxygen content of the water at the cool, deep levels where trout seek refuge during the hot months.

Developed with funds provided by two private sponsors, the new procedure may enable many States and Provinces to provide more abundant trout fishing in the northern lakes region.

The five northern Wisconsin lakes were studied for 2 years prior to their fertilization with lime. Each lake was surrounded by bog. Each contained dark, acid water in which a Secchi disk became invisible beyond 5 feet. The cool, deeper water was deficient in oxygen.

Trout were planted in each lake during the 2-year study period. During the hot summer of 1949, large numbers of the trout in the lake with the darkest water died from lack of oxygen and possibly from high temperatures. One month after the treatment with lime, however, it was found that oxygen had become available in the deep water, and a Secchi disk could be seen to a depth of 15 feet. Photometer

readings confirmed the twofold increase in light penetration.

In one experiment, twin lakes were tested. One twin received lime; the other, none. In the latter twin there was winterkill. Increased transparency apparently improves oxygen conditions under the ice sufficiently to carry fish through severe winters and reduces the danger of winterkill in these lakes.

The added bicarbonate also increases the amount of carbon dioxide available for photosynthesis, and in this sense it is a fertilizer. After the initial alkalization, smaller amounts must be added each year to prevent the lake from reverting to an acid condition. The costs are not excessive for lakes of less than 100 acres.

FISH FURUNCULOSIS

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Furunculosis is one of the most destructive diseases of trout and salmon. It is a general infection, a bacteriemia, caused by a bacterium known by the name Aeromonas salmonicida (formerly Bacterium salmonicida).

As late as 1944, O'Donnell stated, in his excellent article on the control of disease in trout hatcheries, that "the only known method of absolute control of A. salmonicida involves the complete elimination of all fish from the hatchery, thorough disinfection of the hatchery, the rebuilding of a new stock of disease-free fish, and the maintenance of disease-free conditions throughout all future operations." As furunculosis is an acute and rapidly spreading disease, its presence usually has meant the loss of all infected brook and brown trout, Atlantic salmon, and other susceptible species.

Since Gutsell discovered in 1946 that sulfamerazine -- one of the new sulfonamides -- was extremely effective in the control of furunculosis, the approach to control of this deadly disease of salmonid fishes has been entirely changed. Further studies conducted at Leetown by Gutsell, Snieszko, and Friddle have put the treatment of this disease on a rational basis through determination of the exact dosage of the drug, length of treatment, and the reaction of the fish to the treatment.

Production of 1 pound of legal-sized brook or brown trout is generally assumed to cost about 1 dollar, and 75 to 80 percent of the fish in an infected lot can be saved if the treatment with sulfonamides is started in time and carried out exactly as recommended. Therefore, this new treatment not only makes possible great financial savings in fish production but also saves most of the fish for stocking or commercial purposes. If this treatment were not available, very few fish from an infected lot would be left to a hatchery.

It is recommended that treatment last for about 3 weeks at a maximum rate of 10 grams of sulfamerazine per 100 pounds of fish per day. This means that treatment of 1 pound of trout would cost about 6 cents, at the present cost of the drug. Should 25 percent of the fish be lost anyhow, the cost of treatment of the surviving trout would not exceed 8 cents per pound. This is little in comparison with the cost of production.

The economic advantage of the treatment with sulfonamides is so great that private, State, and Federal hatcheries in which furunculosis is endemic are finding it more expedient to treat the fish year after year than to resort to the use of sanitary measures.

The popularity of sulfonamide treatment of furunculosis is so great that many private and State hatcheries are ordering from feed manufacturers pelleted fish food that contains sulfamerazine.

Needed is more work on mineral deficiencies, especially "trace" elements, in fish.

CLEARING HOUSE

Artificial fertilization of lakes and ponds: review of literature.--J. A. Maciolek.
Spec. Sci. Rept., Fish.
No. 113. 41 pp.
January 1954. (processed)

Seasonal abundance of clam larvae in Rhode Island waters, 1950-52.--W. S. Landers.
Spec. Sci. Rept., Fish.
No. 117. 29 pp., illus.
March 1954. (processed)

Angling on Little Pigeon River, Great Smoky Mountains National Park, 1953.--R. E. Lennon.
Spec. Sci. Rept., Fish.
No. 121. 27 pp., illus.
April 1954. (processed)

Phosphorus content of waters along the west coast of Florida.--H. W. Graham, J. M. Amison, and K. T. Marvin.
Spec. Sci. Rept., Fish.
No. 122. 43 pp., illus.
April 1954. (processed)

Survey of sport fishery projects, 1954.--Compiled in the Branch of Federal Aid.
Circ. 26. 143 pp.
April 1954. (processed)
-- Fish and Wildlife Service
U. S. Department of the Interior
Interior Building
Washington 25, D. C.

Causes of fluctuations in abundance of Connecticut River shad.--R. A. Fredin.
Fish. Bull. 88 (Fish. Bull., Fish and Wildlife Service 54: 247-259). 1954. 15¢.

Use of impounded water for fish culture.--H. E. Johnson and R. F. Brice.
Res. Rept. 35. 35 pp., illus.
1953. 20¢.
-- Superintendent of Documents
Government Printing Office
Washington 25, D. C.

Toxic effects of sulfite waste liquor on young salmon.--R. W. Williams, E. M. Mains, W. E. Eldridge, J. E. Lasater. Edited by G. A. Holland.
Res. Bull. 1. 111 pp., illus.
Dec. 1953.

Investigations of mortalities to downstream migrant salmon at two dams on the Elwha River.--D. E. Schoeneman and C. O. Junge, Jr.
Res. Bull. 3. 51 pp., illus.
April 1954.
-- Washington Department of Fisheries
1308 Smith Tower
Seattle, Washington.

Traité de pisciculture.--Marcel Huet.
2d edition. xii, 371 pp., illus.
1953. $5.40, $6.60; postage.
-- La Vie Rustique
299, Avenue Georges Henri, 299
Bruxelles, Belgium.

The western end of Lake Erie and its ecology.--T. H. Langlois.
xx, 479 pp., illus.
lithoprinted. $10. 1954.
-- J. W. Edwards, Publisher, Inc.
Ann Arbor, Michigan.

Life history and economic importance of a burrowing mayfly, Hexagenia limbata, in southern Michigan lakes.--B. P. Hunt.
Bull. Inst. Fish. Res. 4.
151 pp., illus. Nov. 1953.

Fishing in twelve Michigan lakes under experimental regulations.--Kenneth E. Christensen.
Misc. Pub. 7.
46 pp., illus. Nov. 1953.
-- Institute for Fisheries Research
Michigan Department of Conservation
University of Michigan
Ann Arbor, Michigan.

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